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JCAA/JG-PP LEAD-FREE SOLDER PROJECT: COMBINED ENVIRONMENTS TEST

by
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Abstract

Combined environments testing was conducted for the Joint Council on Aging Aircraft/Joint Group on Pollution Prevention Lead-Free Solder project. The purpose of the project was to validate and demonstrate lead-free solders as potential replacements for conventional tin-lead solders used on circuit card assemblies against the requirements of the aerospace and military electronics community.

The solder alloys tested include: Sn3.9Ag0.6Cu, Sn3.4Ag1.0Cu3.3Bi, Sn0.7Cu0.05Ni and Sn37Pb. These solder alloys were used to assemble various components on three different printed wiring board test vehicles: manufacture, rework and hybrid. The test vehicles were subjected to a combined environments test consisting of thermal cycling from –55 to +125 degrees Celsius at a ramp rate of 20 degrees Celsius per minute, dwell at the temperature extremes for 15 minutes and pseudorandom vibration of 10 g_{rms} for the last 10 minutes of the dwell periods. After every 50 cycles, the vibration level was increased by 5 g_{rms} until a maximum of 55 g_{rms} was reached. The test vehicles were electrically monitored using event detectors.

The solder joint failure data of a given component type, component finish and solder alloy were evaluated using Weibull analysis. The reliability of the lead-free solder alloys was compared to the baseline tin-lead (Sn37Pb) solder alloy.

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Foreword

The use of tin-lead solders in defense electronics manufacturing is threatened by environmental regulatory actions and free market forces. Although currently exempt from legislation, there is a concern that the use of lead in aerospace and military electronics may be banned in the future. Even with an exemption, aerospace and military electronics may still be impacted by the consumer electronics manufacturer's move to lead-free products. As more commercial electronics manufacturers move to lead-free technology to comply with the environmental regulation, aerospace and military programs will find it more difficult to procure electronic components fabricated with tin-lead solder. While work has been done to determine lead-free reliability for commercial electronic products, there has been little data published on the reliability of lead-free solders on high reliability, high performance military electronic products. In November 2000, a project was initiated by the Department of Defense (DoD) and a consortium of the DoD, National Aeronautics and Space Administration (NASA), and several defense electronics contractors was formed to evaluate lead-free solders to conduct solder joint reliability testing of lead-free solder alloys.

The combined environments test was one of several tests selected by the consortium to determine the reliability of lead-free solders under combined thermal cycle and vibration environmental exposures. The test was conducted from October 7, 2004 through June 3, 2005 using a QualMark Model OVS-4 HALT/HASS chamber located in the Raytheon Environmental Test Laboratory in McKinney, Texas. The combined environments test was performed utilizing a temperature range of –55 to 125 degrees Celsius with 20 degree Celsius per minute temperature ramp. The dwell time at each temperature extreme was fifteen minutes. A ten g_{rms} pseudorandom vibration was applied for the last 10 minutes of both the cold and hot soaks. After 50 cycles, the vibration levels were incremented by 5 g_{rms} and cycling was continued for an additional 50 cycles. This process was repeated until a significant number of solder joints failed or 55 g_{rms} was reached. ETL personnel ran 15 test vehicles in the chamber at a time. The 45 test vehicles were tested in three different groups.

The test vehicle was a circuit card assembly designed per IPC-SM-785 and IPC-9701 to evaluate solder joint reliability. The test vehicle printed circuit board was designed with daisy-chained pads that are complementary to the daisy chain in the components. Therefore, the solder joints on each component are part of a continuous electrical pathway that is monitored during testing by an event detector. The test vehicles were assembled per ANSI/J-STD-001, Class 3 requirements by BAE Systems. There were three variations of the test vehicle; "manufacture", "rework" and "hybrid". The purpose of the "manufacture" test vehicle was to simulate the construction of current military circuit card assembly technology. The purpose of the "rework" test vehicle was to simulate the construction of older, legacy military circuit card assembly technology for testing the suitability of using lead-free solder in repairing older hardware built with tin-lead solder. The purpose of the "hybrid" test vehicle was to test the hybrid and CSP components that were left off of the "manufacture" test vehicles.

The lead-free solder alloys tested were tin-silver-copper, tin-silver-copper-bismuth and tin-copper. The baseline solder alloy was eutectic tin-lead. Tin-silver-copper solder alloys are currently the leading choice of the electronics industry for lead-free solder. Tin-silver-copper-bismuth alloy was tested because bismuth has been shown to enhance the long-term thermal cycle reliability of solder joints. Tin-copper solder alloys are commonly used in wave solder applications by consumer electronics manufacturers.

The acceptance criteria for the lead-free solder alloys was solder joint reliability better than or equal to eutectic tin-lead controls at ten percent Weibull cumulative failures.

Summary

The manufacture and rework test vehicles were inspected per J-STD-001, Class 3 requirements by a Quality Control Inspector from Circuit Card Assembly Shop in McKinney. The inspector documented a number of suspected solder defects on lead-free as well as tin-lead solder joints based on their grainy appearance. The manufacture test vehicles were tested for 550 cycles. The rework test vehicles were only tested for 536 cycles because the chamber experienced an over temperature condition during cycle 537. The hybrid test vehicles were tested for 500 cycles.

The failure data were analyzed by component type, component finish and solder alloy using 2-parameter Weibull analysis with ReliaSoft Weibull++6 software. The only samples that met the acceptance criteria were:

- Tin-silver-copper-bismuth soldered tin-silver-copper-bismuth surface finish CLCC-20 on "manufacture" test vehicles
- Tin-silver-copper-bismuth soldered tin-lead surface finish CLCC-20 on "manufacture" test vehicles
- Tin-silver-copper-bismuth soldered tin surface finish TQFP-144 on "manufacture" test vehicles
- Tin-silver-copper-bismuth soldered tin-copper surface finish TSOP-50 on "manufacture" test vehicles
- Reworked tin-silver-copper balled BGA-225 on "rework" test vehicles
- Tin-silver-copper soldered tin-silver-copper surface finish hybrid-30 on "hybrid" test vehicles
- Tin-silver-copper-bismuth soldered tin-silver-copper-bismuth surface finish hybrid-30 on "hybrid" test vehicles

Overall, the component type had the greatest effect on solder joint reliability performance. The plated-through-hole components proved to be more reliable than the surface mount technology components. The plated-through holes, PDIP-20 and PLCC-20 components performed the best. The CSP-100 and hybrid components had the worst solder joint reliability of the components tested.

The solder alloy had a major secondary effect on solder joint reliability. In general, tin-silver-copper-bismuth soldered components were more reliable than the tin-lead soldered controls with the exceptions of some components with lead contamination in the solder joints. In general, tin-silver-copper soldered components were less reliable than the tin-lead soldered controls. The lower reliability of the tin-silver-copper solder joints does not necessarily rule out the use of tin-silver-copper solder alloy on military electronics based on these results.

The impact of tin-lead contamination on the lead-free solder alloy reliability was mixed. For tin-silver-copper, the effects of tin-lead contamination were minimal. For tin-silver-copper-bismuth solder alloy, the effects of tin-lead contamination were much greater. There was major degradation in solder joint reliability on TSOP-50 components on manufacture test vehicles and reworked TQFP-208 components and reworked TSOP-50 components on rework test vehicles. The amount of solder joint reliability degradation appears to be inversely proportional to the amount of tin-lead contamination in the solder joint. Therefore, soldering with tin-silver-copper-bismuth solder requires precise control of the lead contamination. The level of control may not be available to military depots and might pose an unacceptable risk to weapons systems. If the lead level on components is not controllable, that may preclude the use of tin-silver-copper-bismuth solder on some or all military electronics.

In general, reworked components were less reliable than the unreworked components. This is especially true with reworked leaded components.

Based on the results of this test, few recommendations are proposed. Lead content must be better understood and controlled if the increased reliability provided by tin-silver-copper-bismuth solder is to be utilized. The results of the CET should be compared to the results of the thermal cycling and vibration testing. If the general results and conclusions are similar, then the CET might be used instead of long term thermal cycling to accelerate the testing of future lead-free solder alloys.

Further investigation in terms of destructive physical analysis and microsection analysis are recommended for the reworked components and in particular the lead-free solder reworked U3 and U57 TQFP-208 components.

Since this test evaluated only solder joint reliability, additional tests must be done to validate assembly reliability with respect to the effect of higher reflow temperatures on printed circuit boards and functional integrated circuits. Additional testing on functional military electronics at the system level is warranted.

Introduction

The use of conventional tin-lead solder in aerospace and military electronics manufacturing is being threatened today by environmental concerns and increasing regulations concerning lead. The regulations began with banning lead additives in gasoline and paint products. This pressure to reduce or remove lead is growing and has lead environmentalists and regulators to focus their attention on eliminating lead from electronics.

The use of tin-lead solders in defense electronics manufacturing is threatened by European, Asian and United States environmental regulatory actions and free market forces. The European Union has adopted legislation that governs the re-use and recycling of electronics waste known as the Waste from Electrical and Electronic Equipment (WEEE) Directive. In addition, Europe has begun implementing the Restriction of Hazardous Substances Directive (RoHS) that bans the use of lead and other substances starting on 1 July 2006. Japan has taken an active role in eliminating lead from consumer electronics with many major Japanese electronics companies announcing the move to lead-free electronics. The U.S. Environmental Protection Agency (EPA) has cited lead and lead compounds as one of the top seventeen chemicals imposing the greatest threat to human health. In implementing Executive Order 12856, the EPA has reduced the reporting threshold for lead and lead compounds to 100 pounds per year thereby increasing reporting by 13% at an estimated average report cost of $23,700 per using facility. This reporting requirement has imposed an estimated added administrative burden of $95 million to the electronics industry. Future U.S. regulatory action may ban all solders containing lead.

Although currently exempt from the European legislation, there is a concern that a legislative body may ban the use of lead in aerospace and military electronics. Even with an exemption, aerospace and military electronics will be impacted by the consumer electronics manufacturer's move to lead-free products. As more commercial electronics manufacturers move to lead-free technology to comply with the European legislation, aerospace and military programs will find it more difficult to procure electronic components fabricated with tin-lead solder. The commercial electronics sector is driving component and board suppliers to provide primarily lead-free surface finishes and alloys. Electronic component manufacturers are switching to lead-free lead finishes. Lead-free components are finding their way into aerospace and military electronics under government acquisition reform initiatives. It is possible that parts with lead-containing finishes may become impossible to procure or the acquisition costs for military grade lead-containing components will become prohibitive. The price of tin-lead solder may rise or the supplies of tin-lead solder may dwindle due to the lower market demand. The aerospace and military community may have little leverage once the lead-free movement gains momentum.

While work has been done to determine lead-free reliability for commercial general and dedicated service electronic products, there has been little comprehensive data published on the reliability of lead-free solders on high reliability, high performance electronic products. In May 2001, a project was initiated by the Department of Defense (DoD). A consortium was formed to evaluate lead-free solders and to determine whether they are suitable for use in high reliability electronics. The consortium consisted of a partnership between the DoD, National Aeronautics and Space Administration (NASA), and several defense electronics contractors to conduct solder joint reliability testing of lead-free solder alloys. The project is managed by the Joint Council on Aging Aircraft (JCAA) and the Joint Group on Pollution Prevention (JG-PP).

Methods, Assumptions and Procedures

Combined Environments Test

The combined environments test (CET) was conducted in accordance with the Joint Test Protocol, "*Joint Test Protocol, J-01-EM-026-P1, for Validation of Alternatives to Eutectic Tin-Lead Solders used in Manufacturing and Rework of Printed Wiring Assemblies*" (Revised April 2004) by Raytheon Materials and Process Engineering. The purpose of the CET was to determine the reliability of solders under combined thermal cycle and vibration environmental exposures. The combined environments test was based on MIL-STD-810F, method 520.2 and a modified Highly Accelerated Life Test (HALT), a process in which products are subjected to accelerated environments to find weak links in the design and manufacturing process. The project stakeholders felt that the combined environments test would provide a quick method to identify comparative reliability differences between the lead-free solder alloys against the eutectic tin-lead solder baseline.

HALT Chamber

The CET was conducted using a QualMark Model OVS-4 HALT/HASS chamber. The chamber is located in the Raytheon Environmental Test Laboratory (ETL) in McKinney, Texas. A photograph of the chamber is provided in Figure 1. The chamber utilizes liquid nitrogen for cooling and nichrome heater elements for heating. The chamber has thermal capability ranges from -100 to 200 degrees Celsius with ramp rates of up to 60 degrees Celsius per minute. The pseudorandom vibration spectra is generated by pneumatically driven vibrators attached to the bottom of the table with maximum levels of 60 G_{rms} and six degrees of freedom (X, Y, & Z axes with rotation in each axis simultaneously). The thermal and vibration environments can be applied separately or combined.

Test Profile

The combined environments test was performed utilizing a temperature range of –55 to 125 degrees Celsius with 20 degree Celsius per minute temperature ramp. The dwell times at each temperature extreme consisted of a six minute temperature stabilization time plus a 15-minute soak. A 10 g_{rms} pseudorandom vibration was applied for the last ten minutes of the cold and hot soaks. The test profile is graphically represented in Figure 2. Testing was continued until sufficient solder joint failure data was generated to obtain statistically significant Weibull plots indicating relative solder joint reliability. If significant failure rates were not evident after 50 cycles, the vibration levels were incremented by 5 g_{rms} and cycling was continued for an additional 50 cycles. This process was repeated until a significant number of solder joints failed or 55 g_{rms} was reached. During cycle 501 through 550, vibration stress was applied continuously at 55 g_{rms} during the thermal cycle. The test was stopped after 550 cycles.

Figure 1 QualMark Model OVS-4 HALT/HASS Chamber

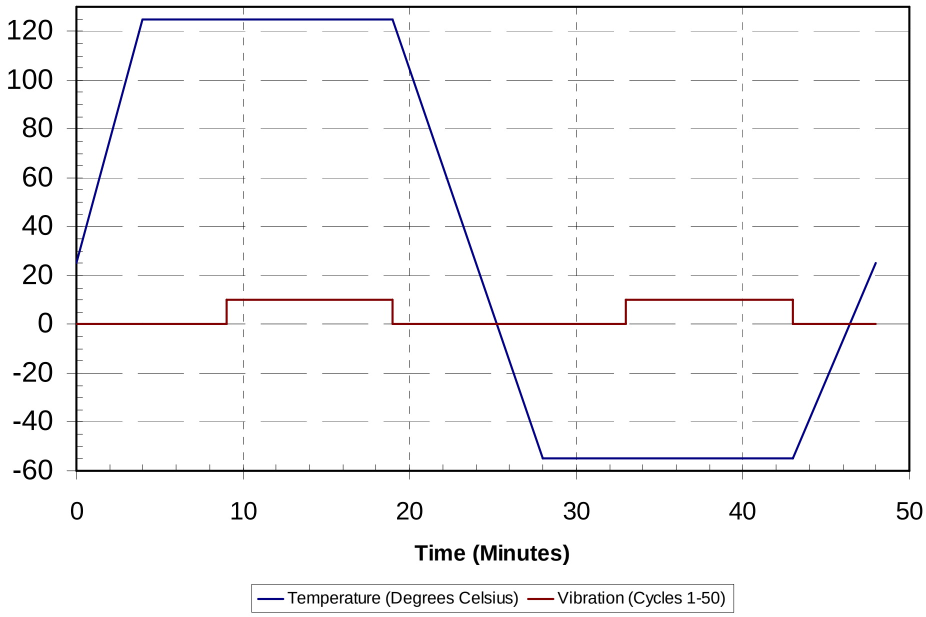

Figure 2 Initial Combined Environments Test Profile

Test Execution

The test vehicles were inspected by a quality control inspector from McKinney Circuit Card Assembly. Ribbon cables were manually soldered to the test vehicle P1 and P2 plated-through holes using eutectic tin-lead solder. Epoxy adhesive was used to bond the ribbon cables to the test vehicles to provide strain relief to the cables.

ETL personnel ran 15 test vehicles in the chamber at a time. The test vehicles were tested in three different groups. Manufacture test vehicles were tested first, and then the rework test vehicles and the hybrid test vehicles were tested last. ETL fabricated aluminum holding fixtures that held nine test vehicles in the first level and six test vehicles on the second level (see Figure 3). The test vehicles were loaded in the fixture in random documented order.

Figure 3 Test Vehicle Layout in Test Chamber

Acceptance Criteria

The team established the CET acceptance criteria for the lead-free solder alloys as solder joint reliability better than or equal to eutectic tin-lead controls at ten percent Weibull cumulative failures.

Results and Discussion

Manufacture Test Vehicles Results and Discussion

The manufacture test vehicles were tested for 550 cycles. The raw data are tabulated in Table 21 starting on page 79. Failures at ten cycles or lower were deemed to be outliers and excluded from analysis by team consensus. The team felt these early life failures were due to manufacturing or testing anomalies and the data should be excluded to prevent skewing the test results. The test vehicles were inspected for lead damage or broken wires. Two wires were noted as broken on two manufacture test vehicles and the data were excluded. No apparent broken leads were observed during post-test inspection at 30x magnification using a binocular microscope.

The data were compiled by test vehicle serial number, component type and component finish (see Table 1). The data show test vehicles 31 and 113 exhibited a lower number of failed components compared to the other test vehicles. This observation suggests these test vehicles may have experienced lower thermal and/or vibration stresses during the testing due to the test vehicle location in the chamber or hardware mounting issues.

Table 1 Number of Failed Components by Manufacture Test Vehicle

Component & Finish	Test Vehicle Serial Number															Total
	30	31	32	33	34	99	100	101	102	103	113	139	140	141	142	
BGA SnAgCu						5	5	5	5	5	2	5	4	4	5	**45**
BGA SnPb	7	1	10	10	10	5	5	4	5	4	1	5	5	5	5	**82**
CLCC SnAgCu						5	5	5	5	5						**25**
CLCC SnAgCuBi											5	5	3	2	5	**20**
CLCC SnPb	10	10	10	10	10	5	5	5	5	5	5	5	5	5	5	**100**
PDIP AuPdNi	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	**3**
PDIP Sn	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
PLCC Sn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TQFP-144 Sn	1	0	3	2	2	2	4	2	3	3	0	3	0	0	5	**30**
TQFP-208 AuPdNi	1	1	2	2	2	0	0	1	1	0	0	1	0	0	3	**14**
TSOP SnCu						5	5	5	5	5	0	2	2	1	4	**34**
TSOP SnPb	5	3	10	10	10	5	5	5	5	5	5	5	5	5	5	**88**
PTH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	**24**	**15**	**35**	**34**	**36**	**32**	**34**	**32**	**34**	**32**	**18**	**32**	**24**	**22**	**38**	**442**

The data were also segregated by component type, component finish and solder alloy (see Table 2). Test vehicles soldered with tin-silver-copper-bismuth solder had fewer solder joints fail (59 percent of the components registering as a failure). Test vehicles soldered with tin-lead solder were second best (63 percent of the components registering as a failure). Lastly, the test vehicles soldered with tin-silver-copper had the worst performance (73 percent of the components registering as a failure). Not enough plated-through-hole components failed to be able to rate the performance of the wave solder alloys.

Table 2 Number of Failed Components by Component, Component Finish and Solder Alloy on Manufacture Test Vehicles

Component & Finish	Solder Alloy					
	SAC Paste	**SAC Wave**	**SACB Paste**	**SnCu Wave**	**SnPb Paste**	**SnPb Wave**
BGA SnAgCu	100% (25 of 25)		80% (20 of 25)			
BGA SnPb	96% (23 of 24)		84% (21 of 25)		76% (38 of 50)	
CLCC SnAgCu	100% (25 of 25)					
CLCC SnAgCuBi			80% (20 of 25)			
CLCC SnPb	100% (25 of 25)		100% (25 of 25)		100% (50 of 50)	
PDIP AuPdNi		0% (0 of 23)		4% (1 of 25)		8% (2 of 25)
PDIP Sn		0% (0 of 25)		4% (1 of 25)		0% (0 of 25)
PLCC Sn	0% (0 of 25)		0% (0 of 25)		0% (0 of 25)	
TQFP-144 Sn	56% (14 of 25)		32% (8 of 25)		32% (8 of 25)	
TQFP-208 AuPdNi	8% (2 of 25)		16% (4 of 25)		32% (8 of 25)	
TSOP SnCu	100% (25 of 25)		36% (9 of 25)			
TSOP SnPb	100% (25 of 25)		100% (25 of 25)		76% (38 of 50)	
PTH		0% (0 of 5)		0% (0 of 5)		0% (0 of 5)
Grand Total	**73% (164 of 224)**	**0% (0 of 53)**	**59% (132 of 225)**	**4% (2 of 55)**	**63% (142 of 225)**	**4% (2 of 55)**

The plated-through-holes, PLCC-20 and PDIP-20 experienced little or no failures. No additional data analysis was conducted on these components. The remaining failure data were analyzed by component type, component finish and solder alloy using ReliaSoft Weibull++6 software. First, the data were analyzed using 2-parameter Weibull analysis. The analysis settings included rank regression on X for analysis method, Fisher Matrix for confidence interval method and median ranks for rank method. The Weibull analysis included the Kolmogorov-Smirnov goodness-of-fit test. The goodness-of-fit test returned the probability that the respective critical value is less than the value calculated. High values, close to one, indicated that there was a significant difference between the theoretical distribution and this data set. Next, the lead-free solder joint reliability was compared to the baseline tin-lead solder joint reliability using the Weibull++6 Tests of Comparison tool. The tool reported the probability of the tin-lead controls lasting longer than the lead-free test case. Finally, the number of cycles to reach one, ten and 63 percent cumulative failures were determined from the Weibull analysis using the Weibull++6 software.

The following sections provide the Weibull analysis for each component type.

BGA-225 Results and Discussion

The Weibull plot for tin-silver-copper soldered tin-silver-copper BGA-225 components is shown in Figure 4. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right of the chart indicates the solder alloy then component finish. The 2-parameter Weibull plot is a poor fit of the data given some of the data points fall outside the confidence limits and the goodness-of-fit result is near one. There appears to be a "stairstep" in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data occur where step increases in the vibration levels occurred as part of the test plan. The test logs were reviewed for potential chamber problems or test procedural issues. No common cause for the stairstep could be identified. Other project members have reported observing this stairstep on other studies involving only thermal cycling.

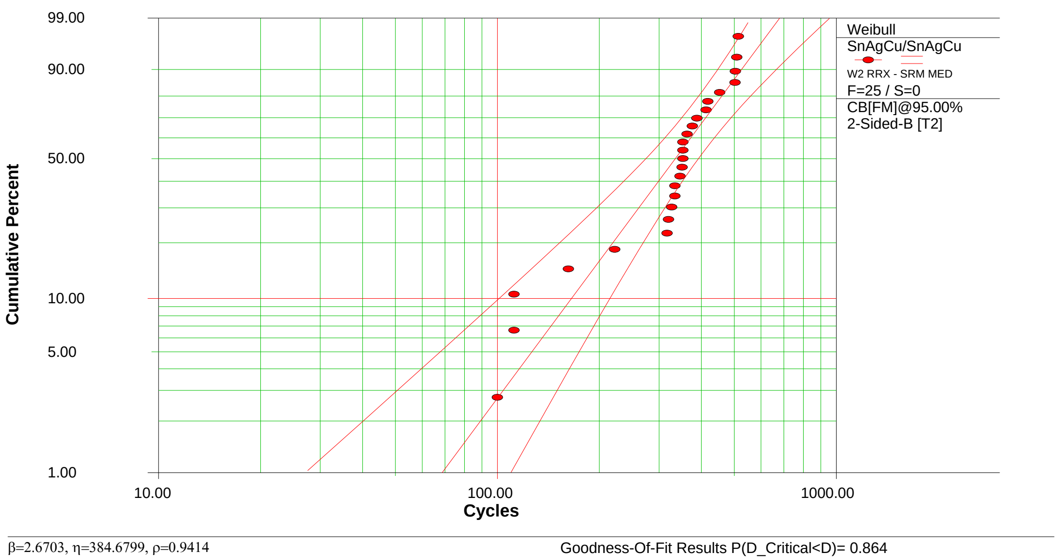

Figure 4 Weibull Plot of Tin-Silver-Copper BGA-225 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper soldered tin-lead BGA-225 components is shown in Figure 5. The 2-parameter Weibull plot is a fair fit of the data since only one datum is outside the 95-percent confidence limits and the goodness-of-fit result is near one-half. There also appears to be a "stairstep" in the data.

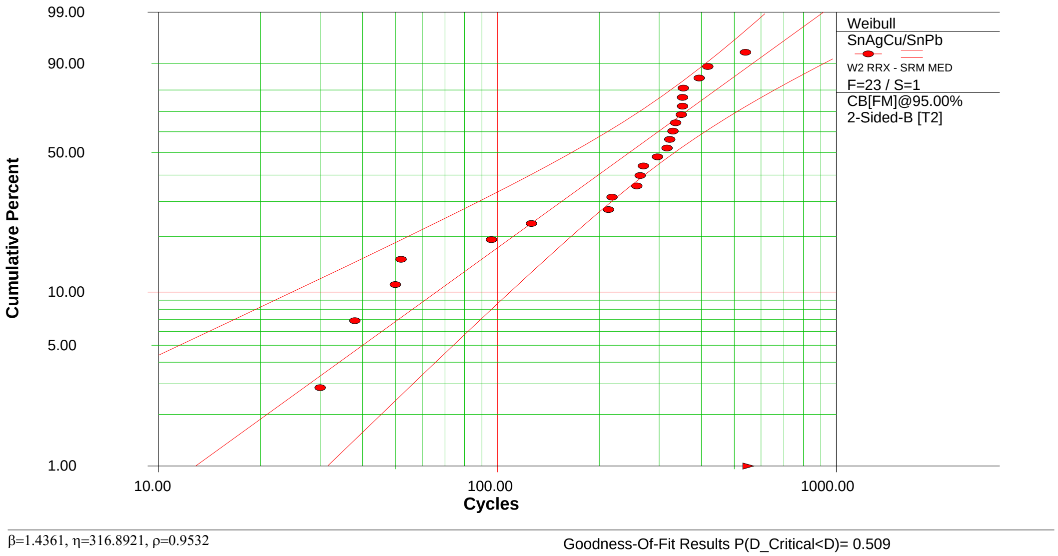

Figure 5 Weibull Plot of Tin-Lead BGA-225 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-silver-copper BGA-225 components is shown is Figure 6. The 2-parameter Weibull plot is a good fit of the data since all of the data fit inside the 95-percent confidence limits and the goodness-of-fit result is relatively low. There appears to be a “stairstep” in the data.

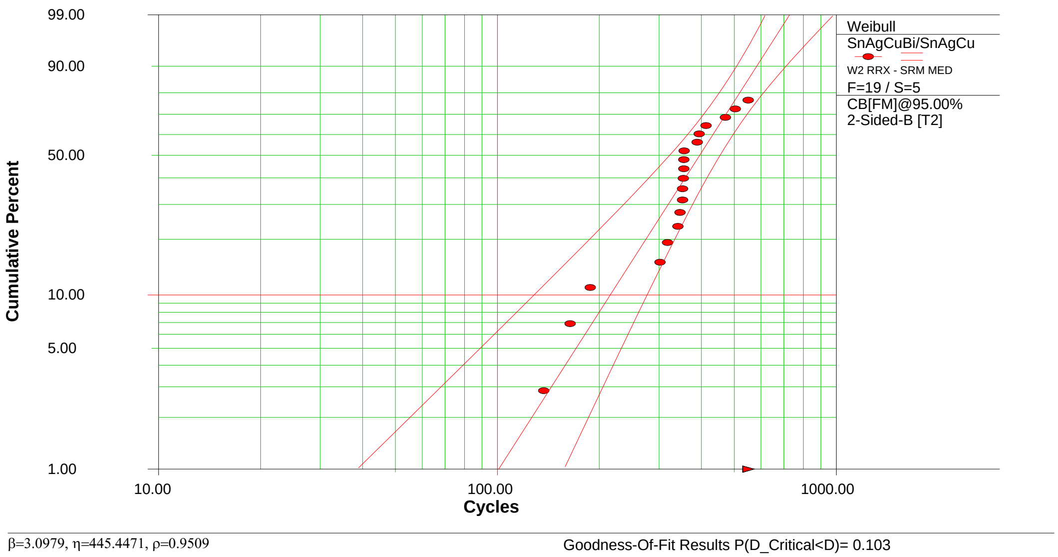

Figure 6 Weibull Plot of Tin-Silver-Copper BGA-225 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-lead BGA-225 components is shown is Figure 7. The 95-percent confidence limits could not be computed for the given Weibull analysis settings. The 2-parameter Weibull plot is a poor fit of the data given the goodness-of-fit result is near one. There appears to be a “stairstep” in the data.

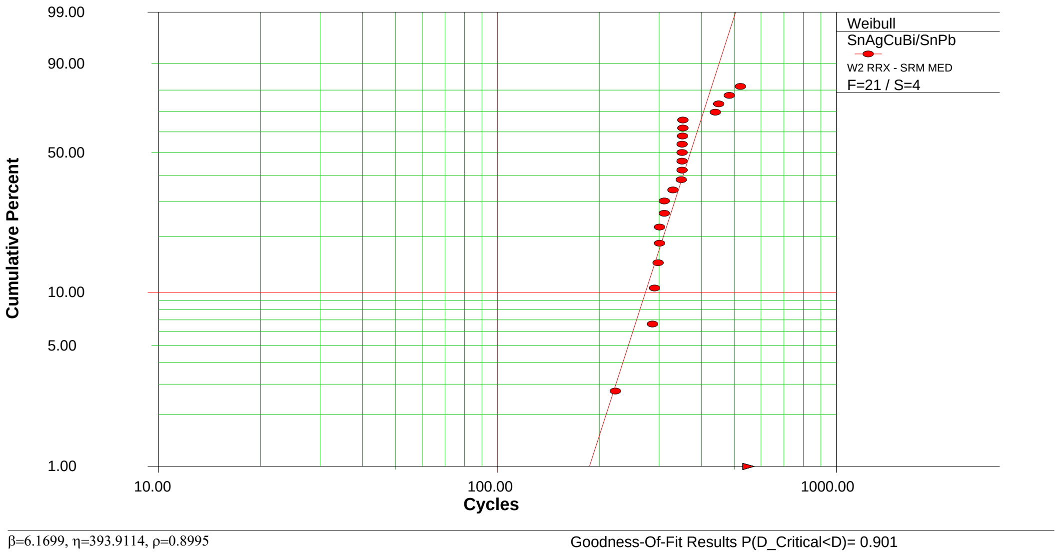

Figure 7 Weibull Plot of Tin-Lead BGA-225 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-lead soldered tin-lead BGA-225 components is shown is Figure 8. The 2-parameter Weibull plot is an excellent fit of the data since all of the data fit inside the 95-percent confidence limits and the goodness-of-fit result is near zero. The improved fit is probably a result of the larger sample size for these components. As a result of the test vehicle design, there were twice as many tin-lead soldered tin-lead BGA-225 components as the lead-free BGA-225 component combinations (50 vs. 25). Even with the improved fit, there is a noticeable stairstep in the data plot.

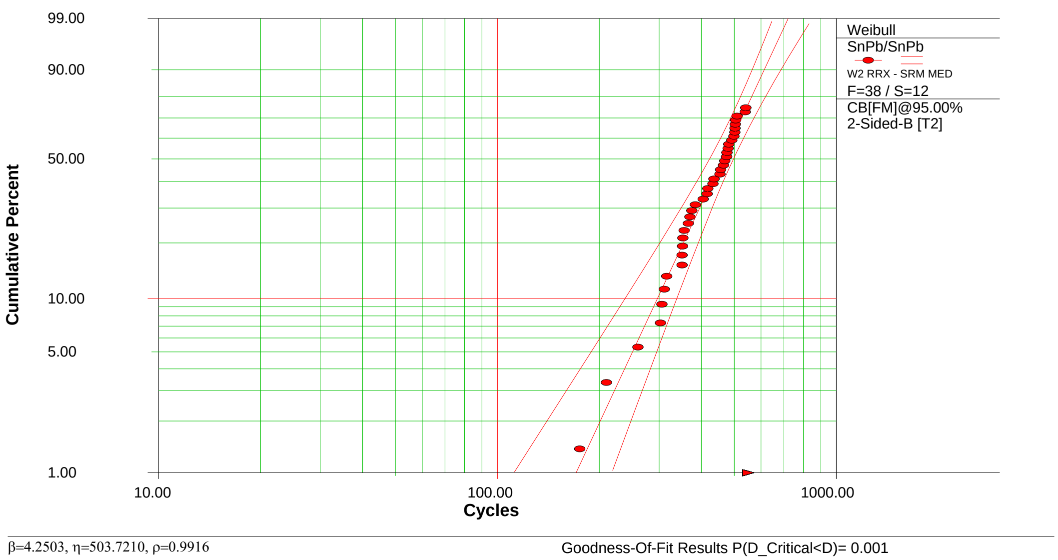

Figure 8 Weibull Plot of Tin-Lead BGA-225 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Several of the Weibull plots were combined to facilitate comparative analysis.

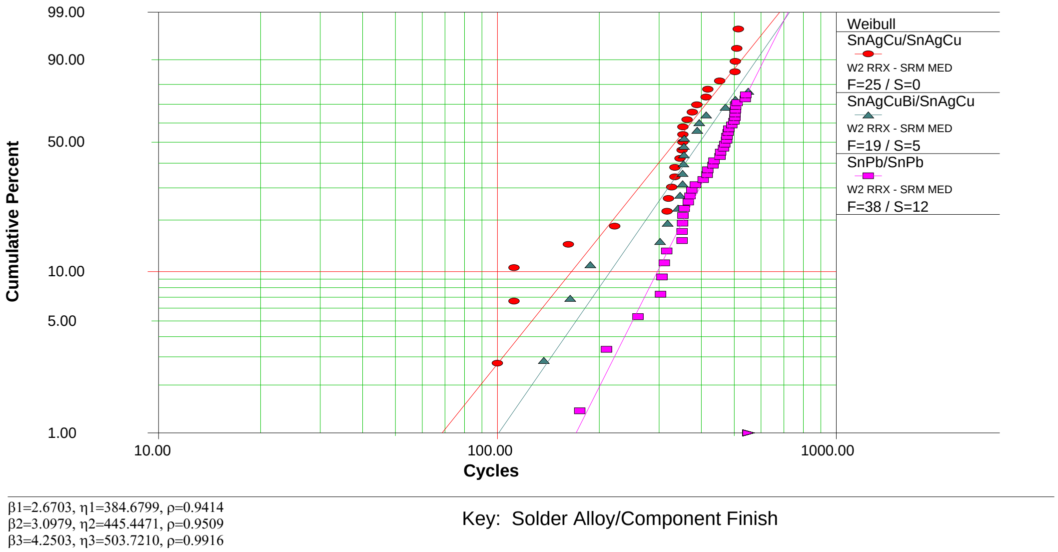

Figure 9 Weibull Plots of Tin-Silver-Copper BGA-225 with Lead-Free Solder Paste Compared to Tin-Lead BGA-225 with Tin-Lead Paste on Manufacture Test Vehicles

Figure 9 contains Weibull plots of lead-free soldered tin-silver-copper BGA-225 components compared to tin-lead soldered tin-lead BGA-225 components. The plot shows tin-lead solder performed best with tin-silver-copper-bismuth solder ranked second and tin-silver-copper solder ranked last.

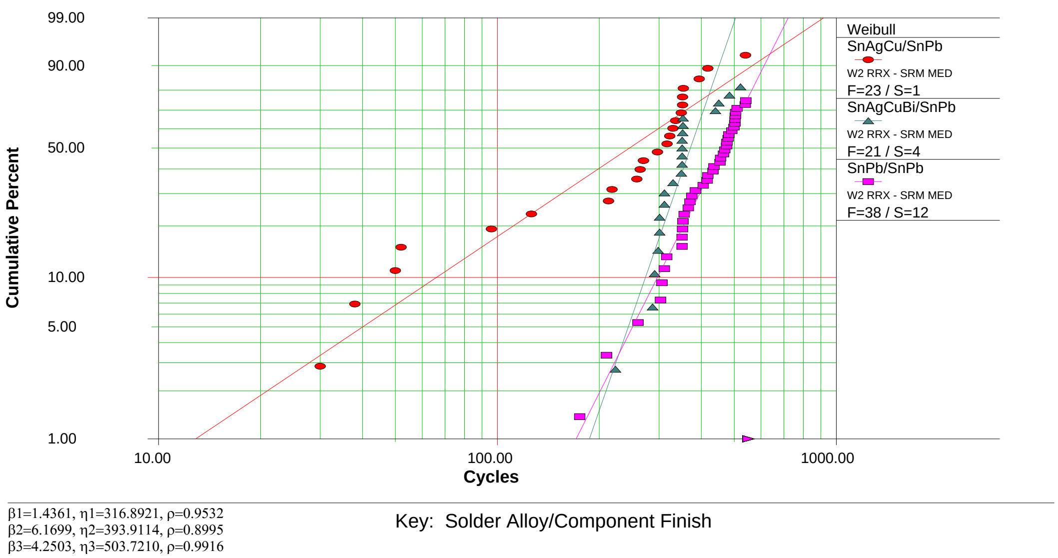

Figure 10 Weibull Plots of Tin-Lead BGA-225 with Lead-Free Solder Paste Compared to Tin-Lead BGA-225 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Figure 10 combines Weibull plots of lead-free soldered tin-lead BGA-225 components compared to tin-lead soldered tin-lead BGA-225 components. The plot shows tin-lead and tin-silver-copper-bismuth solders performing equally well with tin-silver-copper performing the worst.

Figure 11 contains the Weibull plots for all of the combinations of component finish and solder alloy for the BGA-225 components on the manufacture test vehicles. Overall, tin-lead soldered tin-lead BGA-225 components were the most reliable.

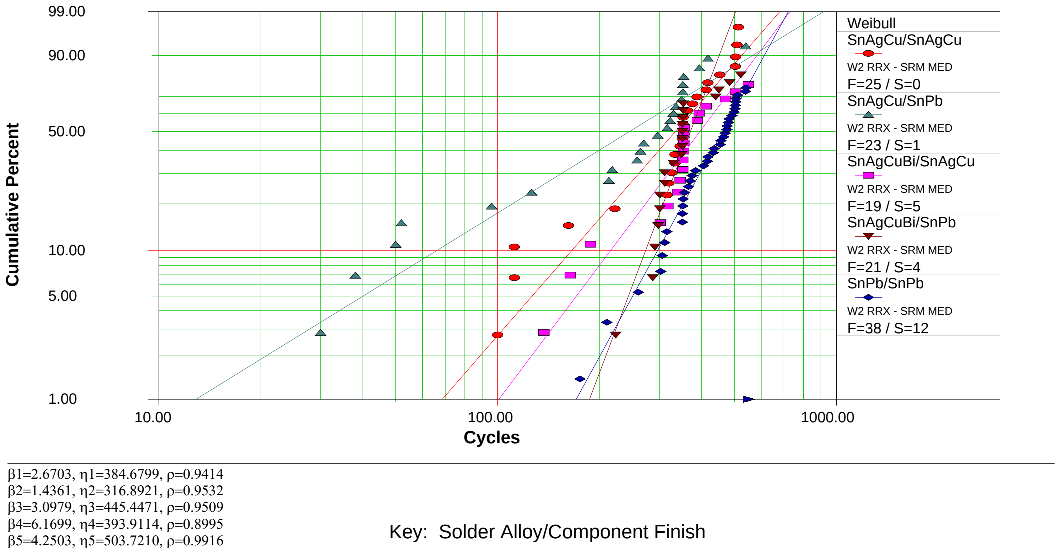

Figure 11 Weibull Plots of BGA-225 on Manufacture Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for BGA-225 on manufacture test vehicles:

- The probability that tin-lead soldered tin-lead BGA-225 components will last longer than tin-silver-copper soldered tin-silver-copper BGA-225 components is 74%.
- The probability that tin-lead soldered tin-lead BGA-225 components will last longer than tin-silver-copper soldered tin-lead BGA-225 is 79%.
- The probability that tin-lead soldered tin-lead BGA-225 components will last longer than tin-silver-copper-bismuth soldered tin-silver-copper BGA-225 components is 63%.
- The probability that tin-lead soldered tin-lead BGA-225 components will last longer than tin-silver-copper-bismuth soldered tin-lead BGA-225 components is 74%.

Therefore, the tests of comparison results show tin-lead BGA-225 components soldered with tin-lead solder will last longer than the BGA-225 components soldered with the lead-free solder alloys tested.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various BGA component finishes and solder alloys are tabulated in Table 3. The N(10%) data are graphically presented in Figure 12. Using the tin-lead soldered tin-lead BGA-225 components N(10%) value as the baseline, the N(10%) values for the tin-silver-copper and tin-silver-copper-bismuth soldered BGA-225 components are less than the baseline and, therefore, <u>do not meet</u> the JTP acceptance criteria. This result is not changed if the N(63%) values are used for the comparison.

Table 3 Number of Cycles to 1, 10 and 63 Percent Failures for BGA-225 on Manufacture Test Vehicles

Solder Paste	BGA Ball	N(1%)	N(10%)	N(63%)
SnAgCu	SnAgCu	69	166	385
SnAgCu	SnPb	13	66	317
SnAgCuBi	SnAgCu	101	215	445
SnAgCuBi	SnPb	187	274	394
SnPb	SnPb	171	297	504

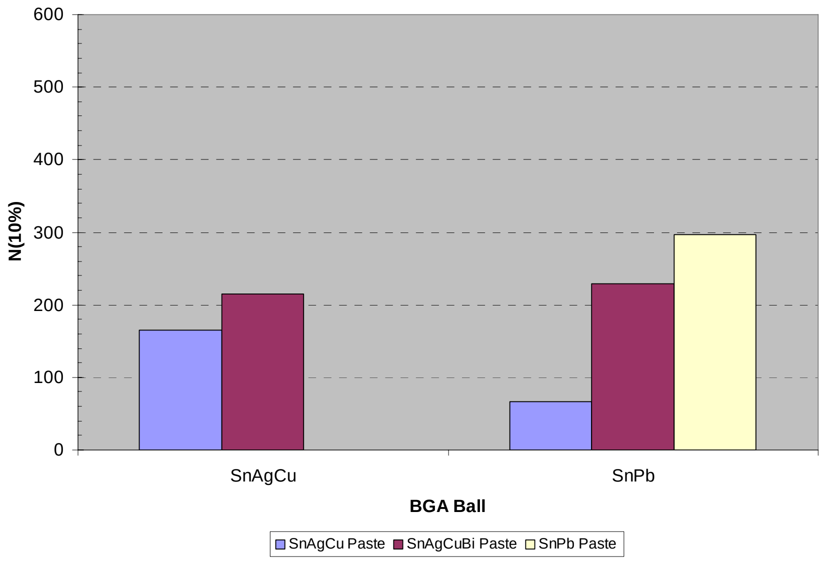

Figure 12 Chart of Number of Cycles to 10% Cumulative Failures by Solder Paste and Lead Finish for BGA on Manufacture Test Vehicles

The effect of tin-lead contamination on tin-silver-copper soldered BGA-225 components is shown in Figure 13. The plots show tin-lead degrades the early life performance of tin-silver-copper while the N(63%) values are similar.

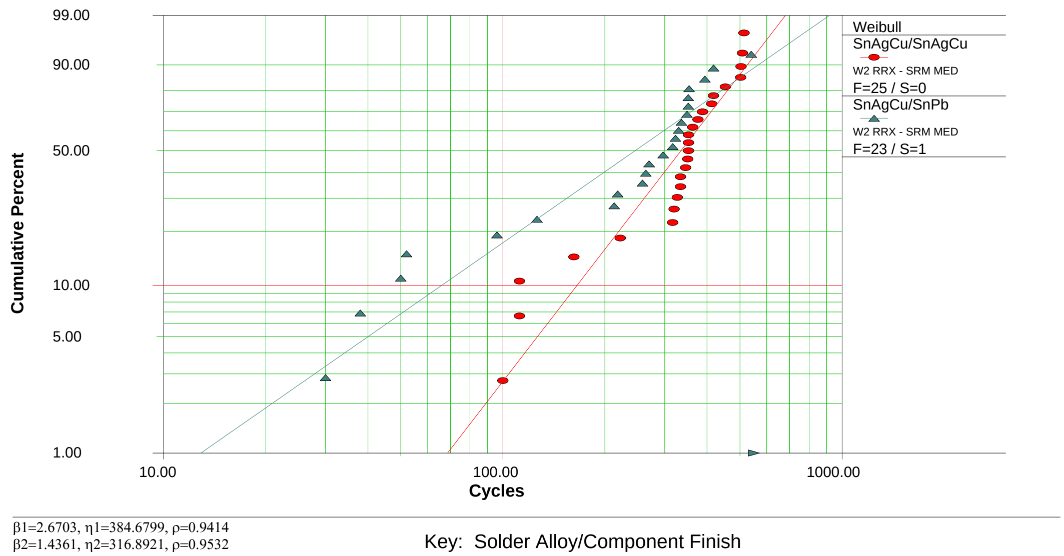

Figure 13 Effect of Tin-Lead Contamination on Tin-Silver-Copper Soldered BGA-225 on Manufacture Test Vehicles

The effect of tin-lead contamination on tin-silver-copper-bismuth soldered BGA-225 components is shown in Figure 14. The plot shows no effect in the reliability performance of tin-silver-copper-bismuth when used to solder tin-silver-copper or tin-lead BGA-225 components.

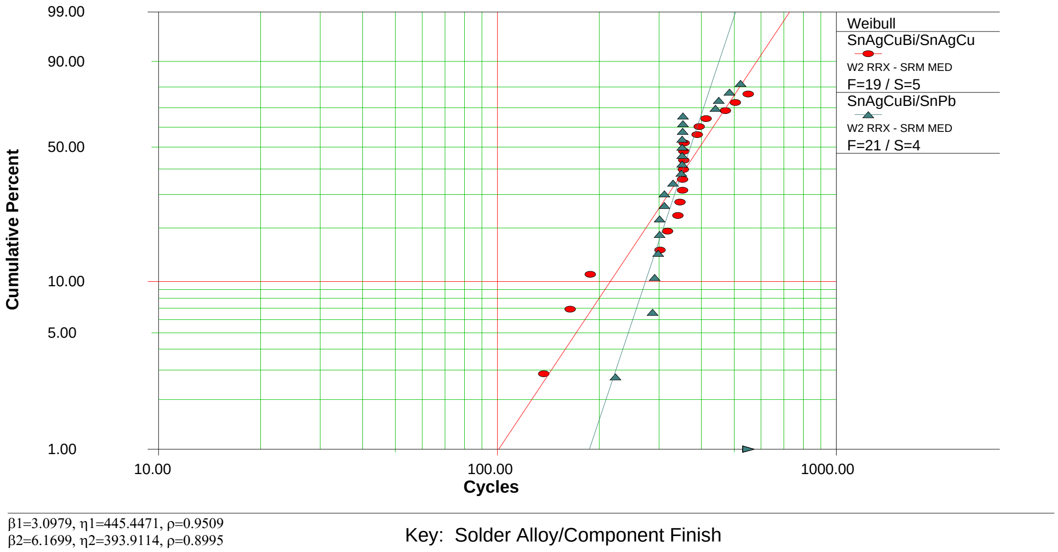

Figure 14 Effect of Tin-Lead Contamination on Tin-Silver-Copper-Bismuth Soldered BGA-225 on Manufacture Test Vehicles

CLCC-20 Results and Discussion

The Weibull plot for tin-silver-copper soldered tin-silver-copper CLCC-20 components is shown in Figure 15. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a fair fit of the data since some of the data points are on the 95-percent confidence limits and the goodness-of-fit result is near 0.5. There appears to be a "stairstep" in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data occur where step increases in the vibration levels occurred as part of the test plan. The test logs were reviewed for potential chamber problems or test procedural issues. No common cause for the stairstep could be identified. Other project members have reported observing this stairstep on other studies involving only thermal cycling.

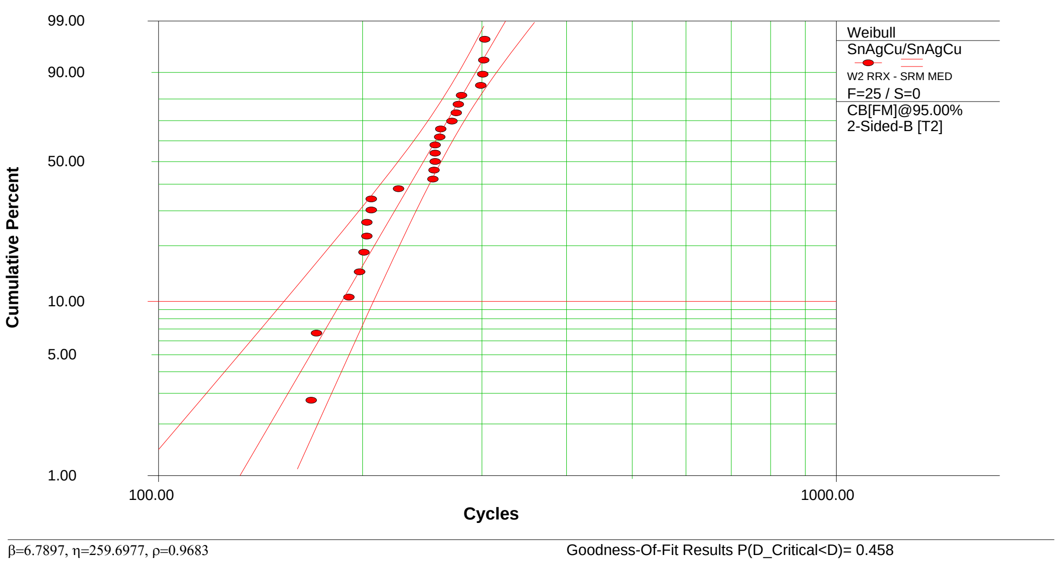

Figure 15 Weibull Plot of Tin-Silver-Copper CLCC-20 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper soldered tin-lead CLCC-20 components is shown in Figure 16. The 2-parameter Weibull regression is a good fit of the data since most of the data reside within the 95-percent confidence limits and the goodness-of-fit result is low.

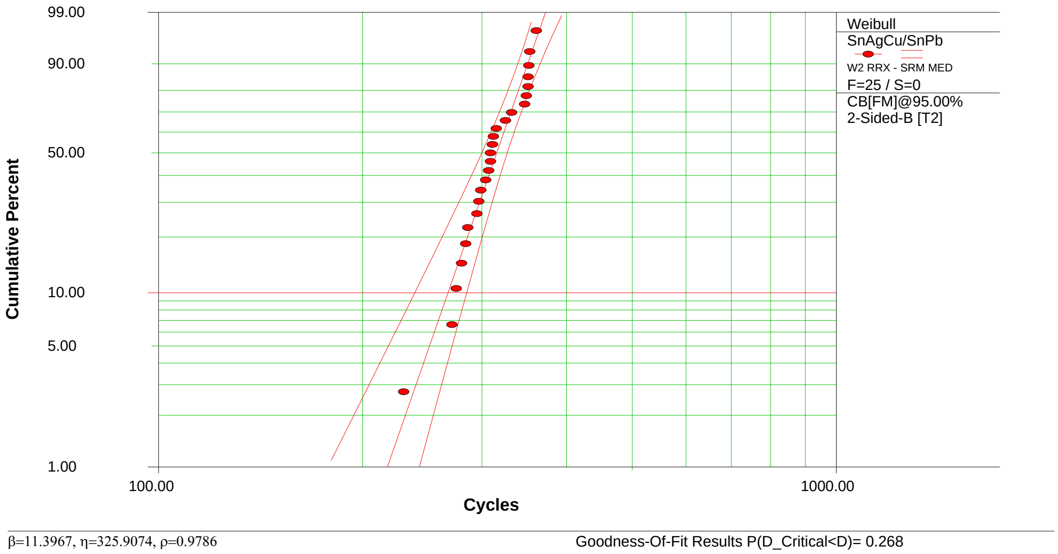

Figure 16 Weibull Plot of Tin-Lead CLCC-20 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-silver-copper-bismuth CLCC-20 components is shown in Figure 17. The 2-parameter Weibull regression is an excellent fit of the data since all data are within the 95-percent confidence limits and the goodness-of-fit result is low.

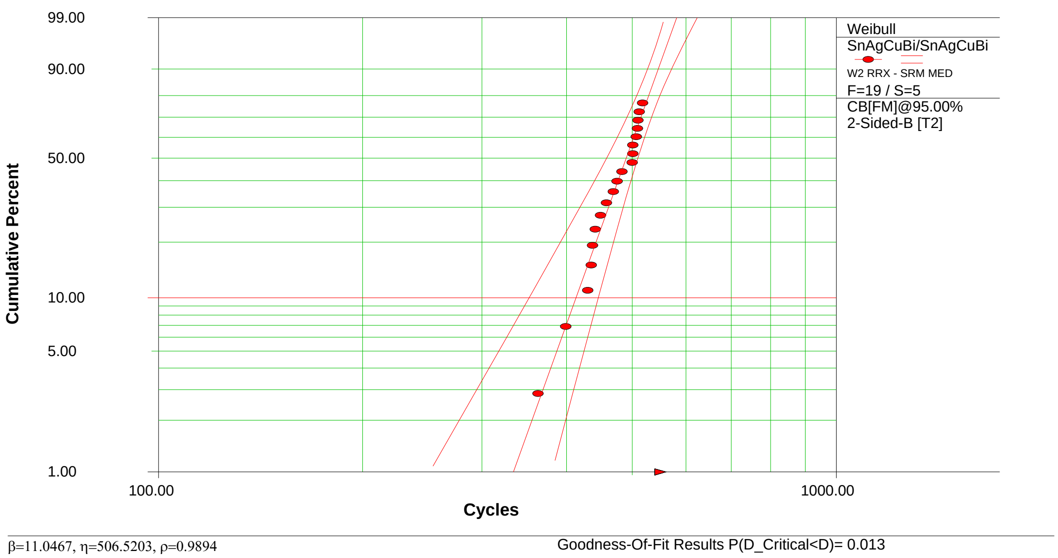

Figure 17 Weibull Plot of Tin-Silver-Copper-Bismuth CLCC-20 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-lead CLCC-20 components is shown in Figure 18. The 2-parameter Weibull regression is a poor fit of the data since many of the data points are outside the 95-confidence limits and the goodness-of-fit result is near one. There appears to be a “stairstep” in the data with vertical jumps near the time where the vibration level increases occurred.

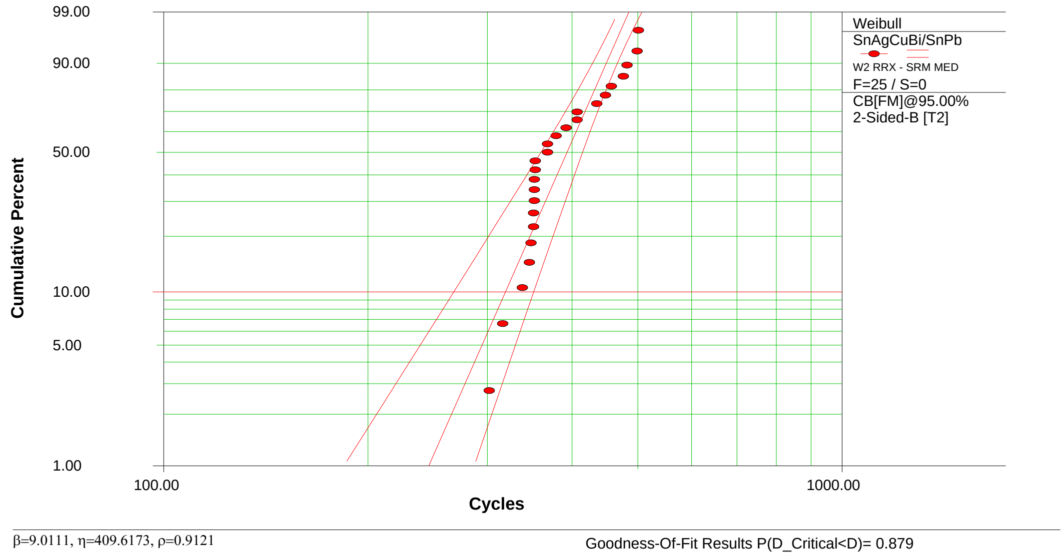

Figure 18 Weibull Plot of Tin-Lead CLCC-20 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-lead soldered tin-lead CLCC-20 components is shown in Figure 19. The 2-parameter Weibull regression is a poor fit of the data since many of the data fall outside the 95-percent confidence limits and the goodness-of-fit results is nearly one. There appears to be a “stairstep” in the data with vertical jumps near the time where the vibration level increases occurred.

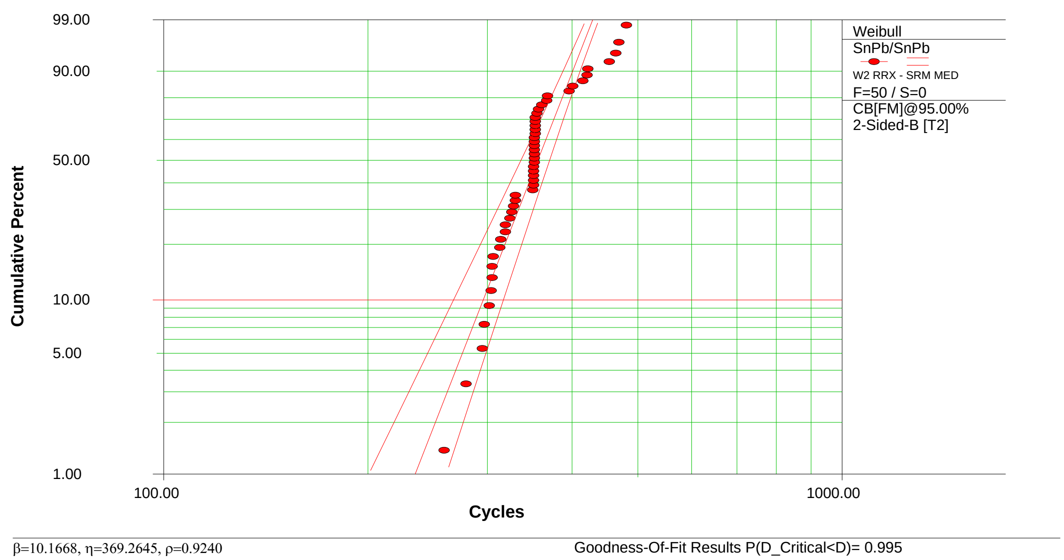

Figure 19 Weibull Plot of Tin-Lead CLCC-20 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Several of the Weibull plots in different lead finish and solder alloys combinations were generated to facilitate comparative analysis. Figure 20 contains Weibull plots of tin-silver-copper soldered tin-silver-copper CLCC-20 components and tin-silver-copper-bismuth soldered tin-silver-copper-bismuth CLCC-20 components compared to tin-lead soldered tin-lead CLCC-20 components. The plot shows a clear delineation in solder joint reliability between the three samples. CLCC-20 components soldered with tin-silver-copper-bismuth solder performed best.

CLCC-20 components soldered with tin-lead solder were ranked second and CLCC-20 components soldered with tin-silver-copper solder ranked last.

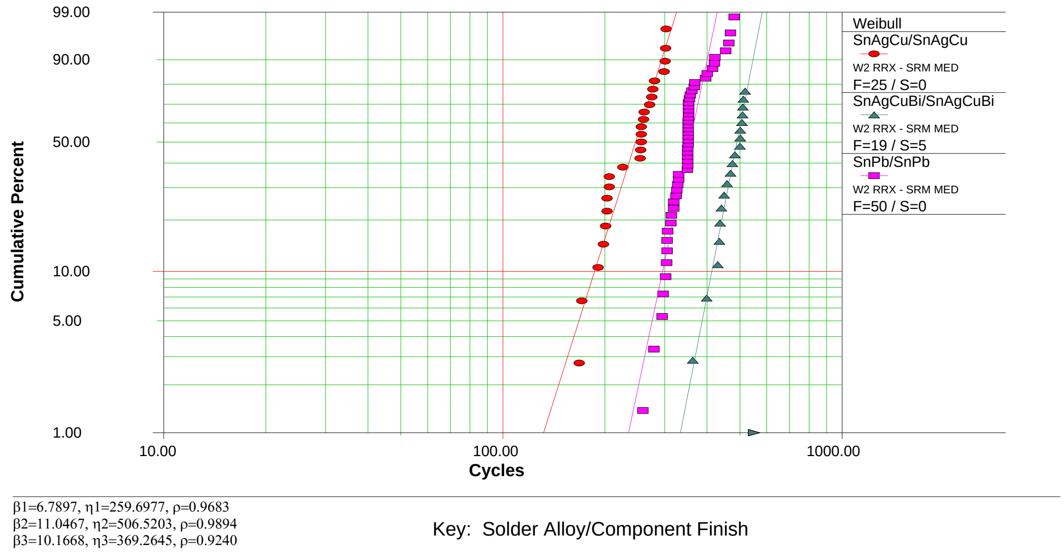

Figure 20 Weibull Plots of Lead-Free CLCC-20 with Lead-Free Solder Paste Compared to Tin-Lead CLCC-20 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Figure 21 combines Weibull plots of lead-free soldered tin-lead CLCC-20 components to tin-lead soldered tin-lead CLCC-20 components. The plot shows similar results in the ranking of reliability performance for the three solder alloys as the previous plot but with smaller separation between the three regression lines.

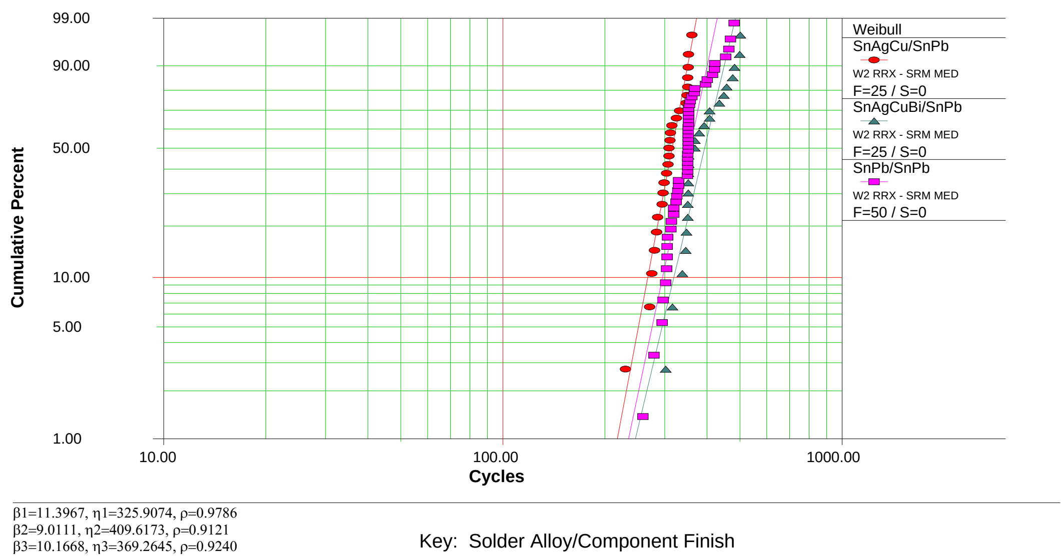

Figure 21 Weibull Plots of Tin-Lead CLCC-20 on Manufacture Test Vehicles

Figure 22 contains the Weibull plots for all of the combinations of component finish and solder alloy for the CLCC-20 components on the manufacture test vehicles. Overall, tin-silver-copper-bismuth solder performed better than tin-lead solder and the tin-lead solder performed better than tin-silver-copper solder. Specifically, the tin-silver-copper-bismuth soldered tin-silver-copper-bismuth CLCC-20 components exhibited the best reliability. The tin-silver-copper-bismuth soldered tin-lead CLCC-20 components were next in the reliability ranking. The tin-lead soldered tin-lead CLCC-20 components were next in the ranking. The tin-silver-copper soldered tin-lead CLCC-20 components were next in the ranking. The tin-silver-copper soldered tin-silver-copper CLCC-20 components were the worst in terms of reliability performance. While the tin-lead finish on the CLCC-20 appears to degrade the reliability when soldered with tin-silver-copper-bismuth solder, the tin-lead finish appears to improve the reliability with tin-silver-copper solder.

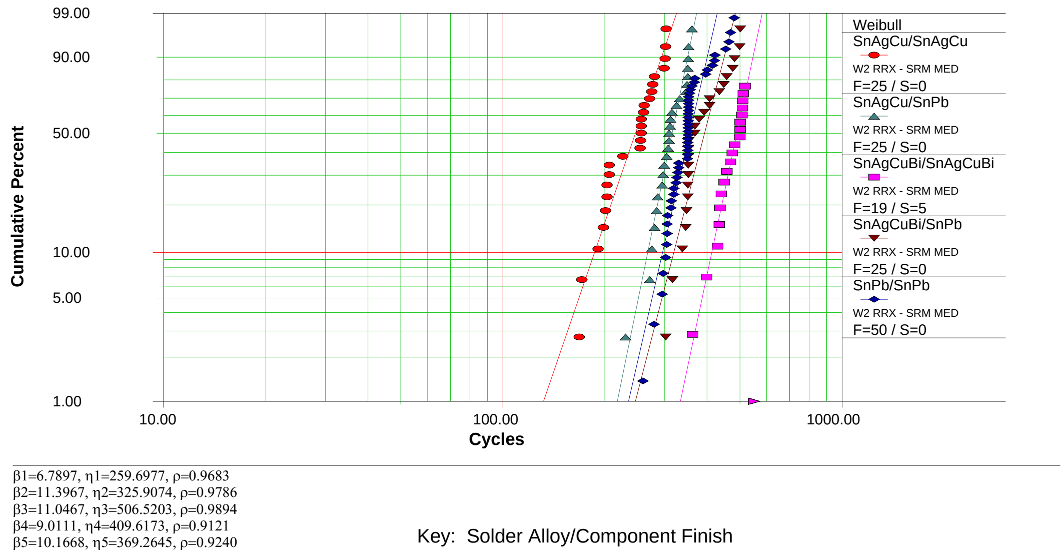

Figure 22 Weibull Plots of CLCC-20 on Manufacture Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for CLCC-20 components on manufacture test vehicles:

- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-silver-copper soldered tin-silver-copper CLCC-20 components is 97%.
- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-silver-copper soldered tin-lead CLCC-20 components is 78%.
- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-silver-copper-bismuth soldered tin-silver-copper-bismuth CLCC-20 components is 3%.
- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-silver-copper-bismuth soldered tin-lead CLCC-20 components is 28%.

Therefore, tin-silver-copper-bismuth soldered tin-silver-copper-bismuth CLCC-20 components and tin-silver-copper-bismuth soldered tin-lead CLCC-20 components will last longer than tin-lead soldered tin-lead CLCC-20 components. The tin-lead soldered tin-lead CLCC-20 components will last longer than the tin-silver-copper soldered tin-silver-copper and tin-lead CLCC-20 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various CLCC-20 component finishes and solder alloys are tabulated in Table 4. The N(10%) data are graphically presented in Figure 23. Using the N(10%) value for tin-lead soldered tin-lead CLCC-20 components as the baseline, the N(10%) values for tin-silver-copper-bismuth soldered CLCC-20 components are greater than the baseline and, therefore, <u>meet</u> the JTP acceptance criteria. The N(10%) values for tin-silver-copper soldered CLCC-20 components are less than the baseline and therefore, <u>do not meet</u> the JTP acceptance criteria. The same results are achieved when the N(63%) values are used as the basis for the comparison.

Table 4 Number of Cycles to 1, 10 and 63 Percent Failures for CLCC-20 on Manufacture Test Vehicles

Solder Paste	CLCC Finish	N(1%)	N(10%)	N(63%)
SnAgCu	SnAgCu	132	186	260
SnAgCu	SnPb	218	268	326
SnAgCuBi	SnAgCuBi	334	413	507
SnAgCuBi	SnPb	246	319	410
SnPb	SnPb	235	296	369

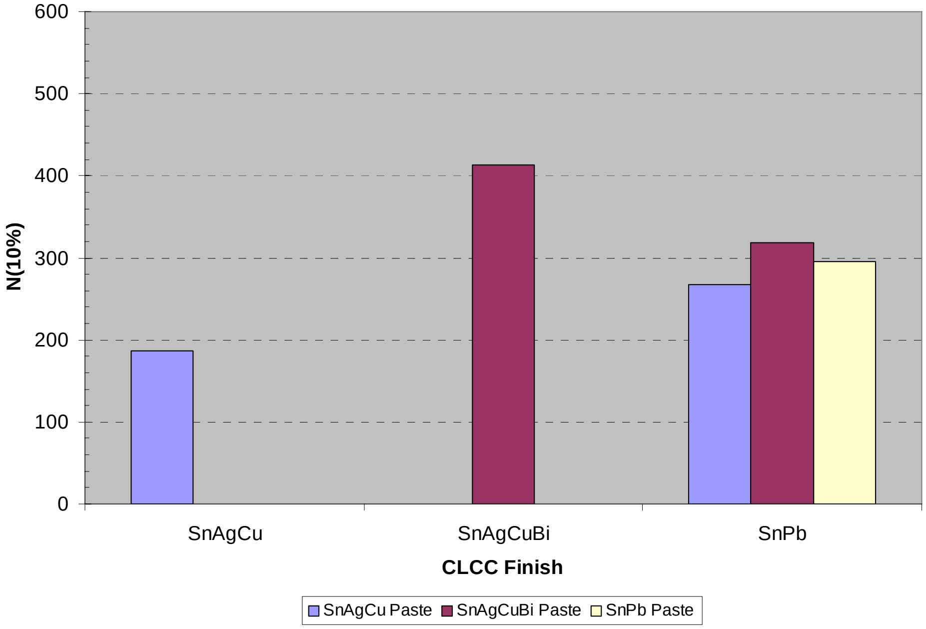

Figure 23 Chart of Number of Cycles to 10% Cumulative Failures by Solder Paste and Lead Finish for CLCC Components on Manufacture Test Vehicles

The effect of tin-lead contamination on tin-silver-copper soldered CLCC-20 components is shown in Figure 24. The presence of tin-lead appears to improve the reliability of the tin-silver-copper solder joint.

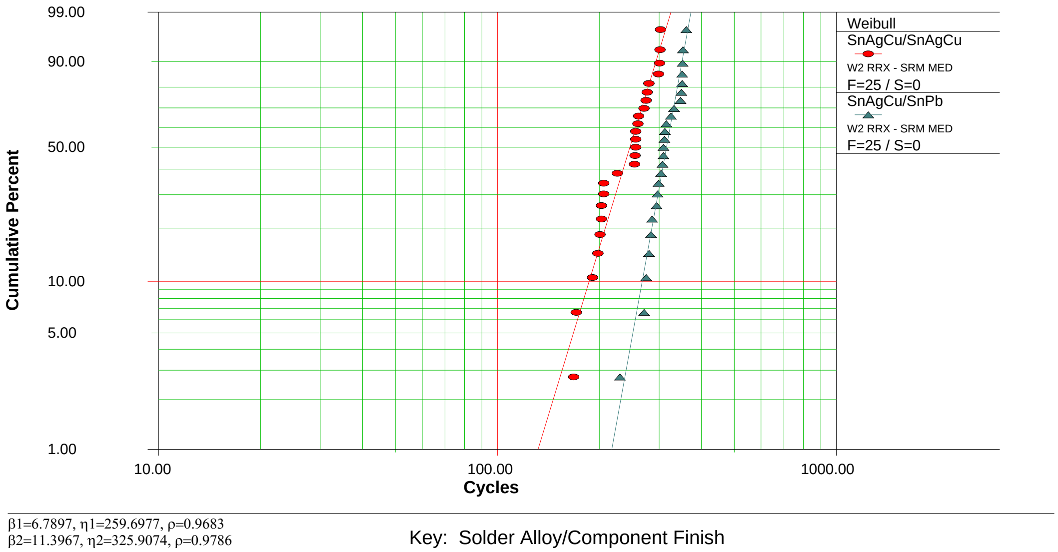

Figure 24 Effect of Tin-Lead Contamination on Tin-Silver-Copper Soldered CLCC-20 on Manufacture Test Vehicles

The effect of tin-lead contamination on the tin-silver-copper-bismuth soldered CLCC-20 components is shown in Figure 25. The presence of tin-lead appears to degrade the reliability of the tin-silver-copper-bismuth solder joint.

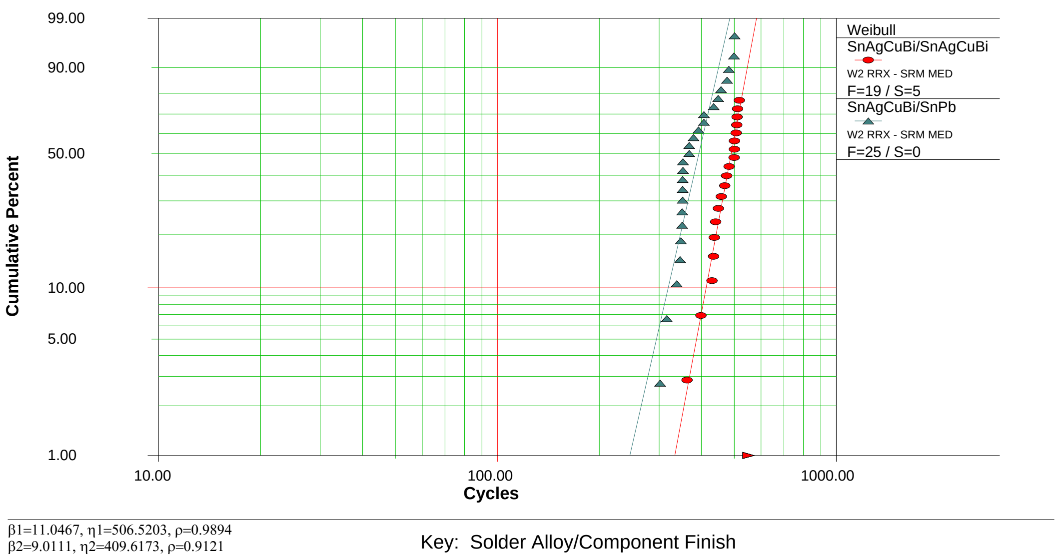

Figure 25 Effect of Tin-Lead Contamination of Tin-Silver-Copper-Bismuth Soldered CLCC-20 on Manufacture Test Vehicles

TQFP-144 Results and Discussion

The Weibull plot for tin-silver-copper soldered tin TQFP-144 components is shown in Figure 26. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. Only 56-percent of these components failed. The 2-parameter Weibull regression is a good fit of the data since the data points are within the 95-percent confidence limits and the goodness-of-fit result is near zero.

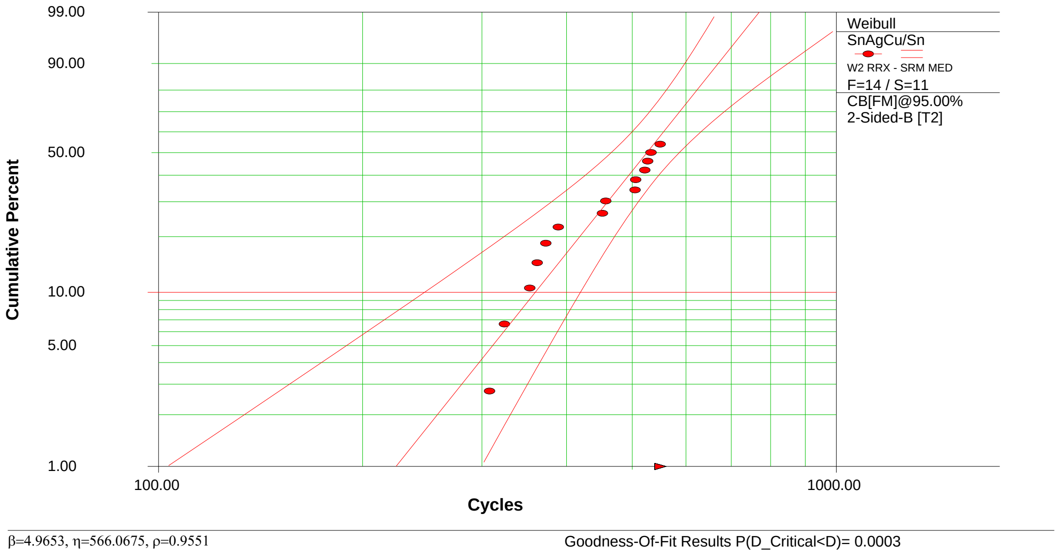

Figure 26 Weibull Plot of Tin TQFP-144 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin TQFP-144 components is shown in Figure 27. Only 32-percent of these components failed. The 63% failure goal was not achieved on this sample set. Therefore, there may not be a sufficient sample size to constitute a sound statistical sample.

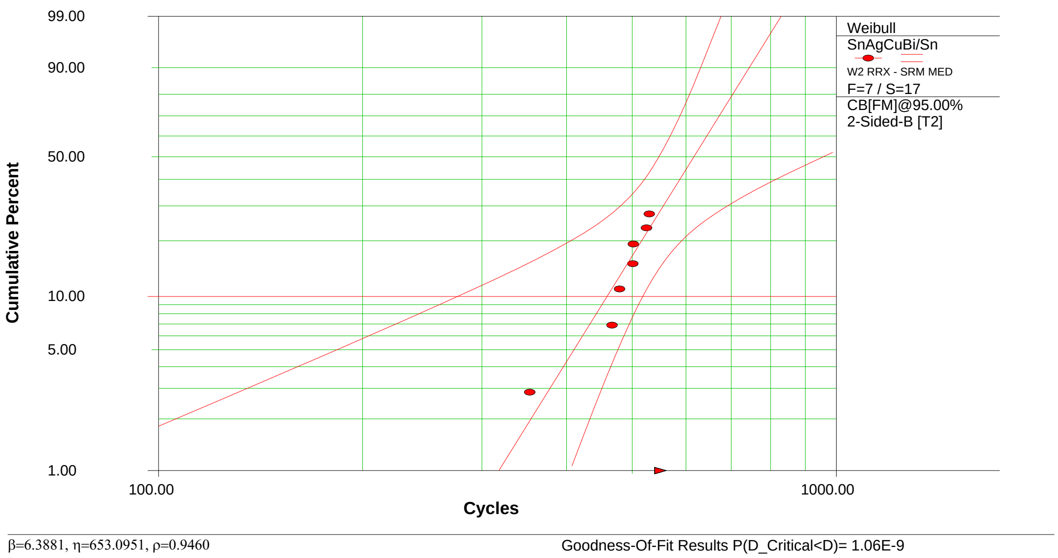

Figure 27 Weibull Plot of Tin TQFP-144 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-lead soldered tin TQFP-144 components is shown in Figure 28. Only 32-percent of these components failed. The 63% failure goal was not achieved on this sample set. Therefore, there may not be a sufficient sample size to constitute a sound statistical sample.

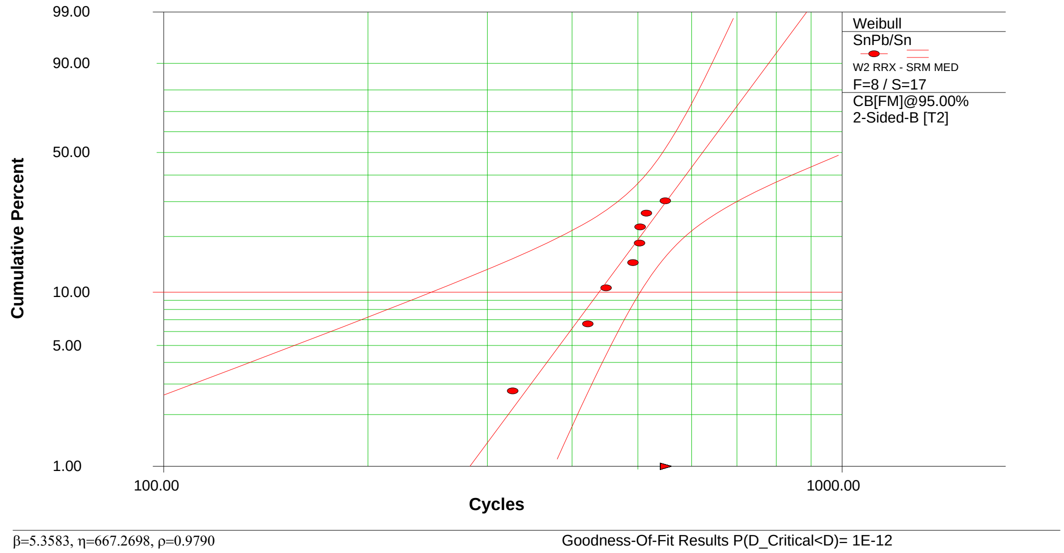

Figure 28 Weibull Plot of Tin TQFP-144 with Tin-Lead Solder Paste on Manufacture Test Vehicles

The Weibull plots for the different solder alloys were combined to facilitate comparative analysis. Figure 29 contains Weibull plots of tin-silver-copper and tin-silver-copper-bismuth soldered tin TQFP-144 components compared to tin-lead soldered tin TQFP-144 components. The plot shows tin-silver-copper-bismuth solder performed equally as well as tin-lead solder and tin-silver-copper solder performed the worst.

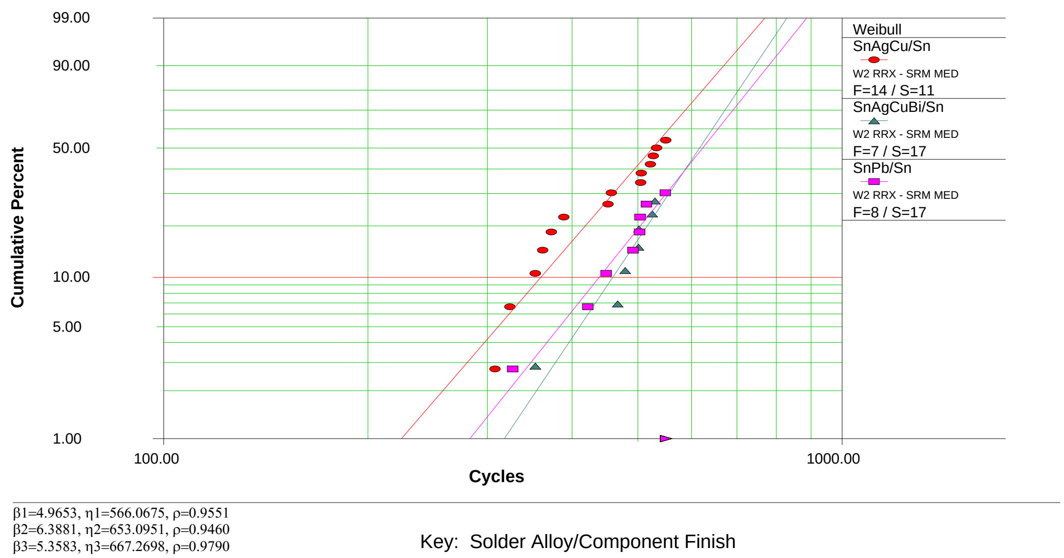

Figure 29 Weibull Plots of Tin TQFP-144 on Manufacture Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for TQFP-144 components on manufacture test vehicles:

- The probability that tin-lead soldered tin TQFP-144 components will last longer than tin-silver-copper soldered tin TQFP-144 components is 71%.

- The probability that tin-lead soldered tin TQFP-144 components will last longer than tin-silver-copper-bismuth soldered tin TQFP-144 components is 52%. Both data sets appear to be from the same population.

Therefore, tin-lead and tin-silver-copper-bismuth soldered tin TQPF-144 components will last longer than tin-silver-copper soldered tin TQFP-144 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the TQFP-144 components are tabulated in Table 5. The N(63%) data are graphically presented in Figure 30. Using the N(10%) value for tin-lead soldered tin TQFP-144 components as the baseline, the N(10%) value for tin-silver-copper-bismuth soldered tin TQFP-144 components is greater than the baseline and, therefore, meets the JTP acceptance criteria. The N(10%) value for tin-silver-copper soldered tin TQFP-144 components is less than the baseline and therefore, does not meet the JTP acceptance criteria. However, if the N(63%) values are used for the comparison, both N(63%) values for the lead-free solder alloys are less than the value for tin-lead solder. Therefore, both lead-free solders do not meet the acceptance criteria if the N(63%) values are used as the basis for comparison.

Table 5 Number of Cycles to 1, 10 and 63 Percent Failures for TQFP-144 on Manufacture Test Vehicles

Solder Paste	Lead Finish	N(1%)	N(10%)	N(63%)
SnAgCu	Sn	224	360	566
SnAgCuBi	Sn	318	459	653
SnPb	Sn	283	438	667

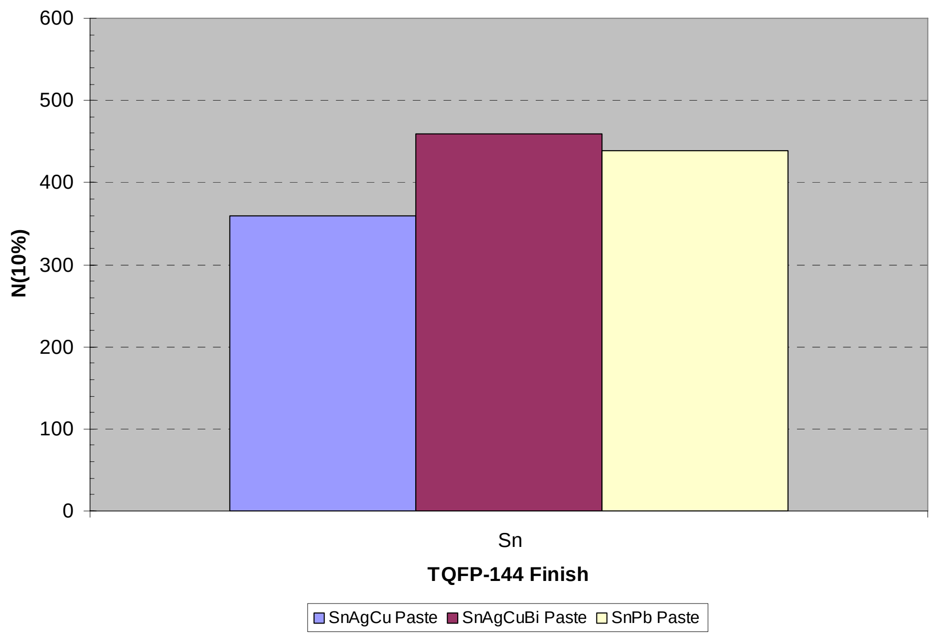

Figure 30 Chart of Number of Cycles to 10% Cumulative Failures by Solder Paste for TQFP-144 on Manufacture Test Vehicles

TQFP-208 Results and Discussion

The Weibull plot for tin-silver-copper soldered gold-palladium-nickel TQFP-208 components is shown in Figure 31. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. Only two of twenty-five components or eight percent of the components failed. There are not a sufficient number of failures for a statistical sample.

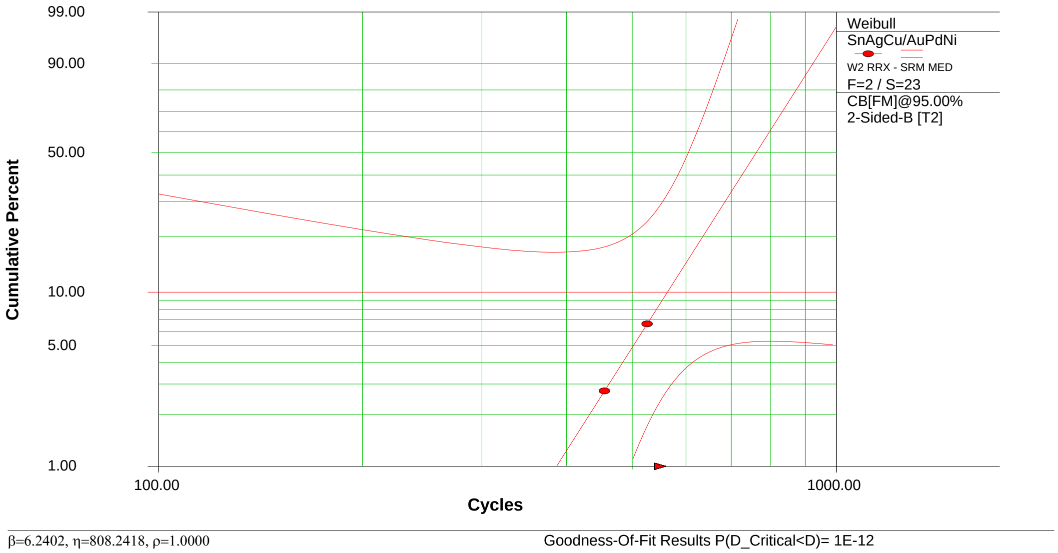

Figure 31 Weibull Plot of Gold-Palladium-Nickel TQFP-208 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components is shown in Figure 32. Only 16-percent of these components failed. Therefore, there is not a sufficient sample size to constitute a sound statistical sample.

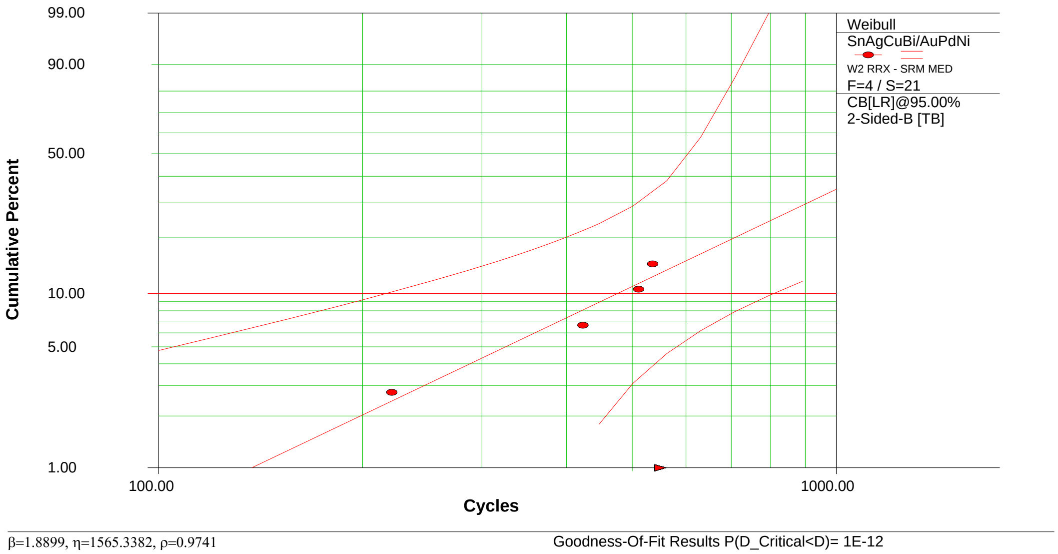

Figure 32 Weibull Plot of Gold-Palladium-Nickel TQFP-208 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-lead soldered gold-palladium-nickel TQFP-208 components is shown in Figure 33. Only 32-percent of these components failed. Therefore, there may not be a sufficient sample size to constitute a sound statistical sample. One datum at 51 cycles appears to be an outlier. The data were re-analyzed without the outlier and plotted in Figure 34.

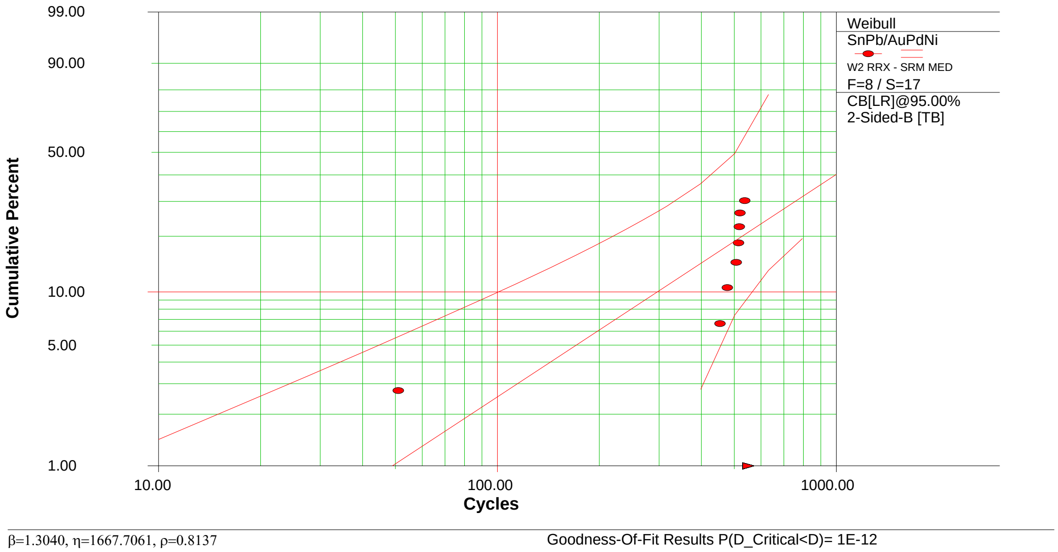

Figure 33 Weibull Plot of Gold-Palladium-Nickel TQFP-208 with Tin-Lead Solder Paste on Manufacture Test Vehicles

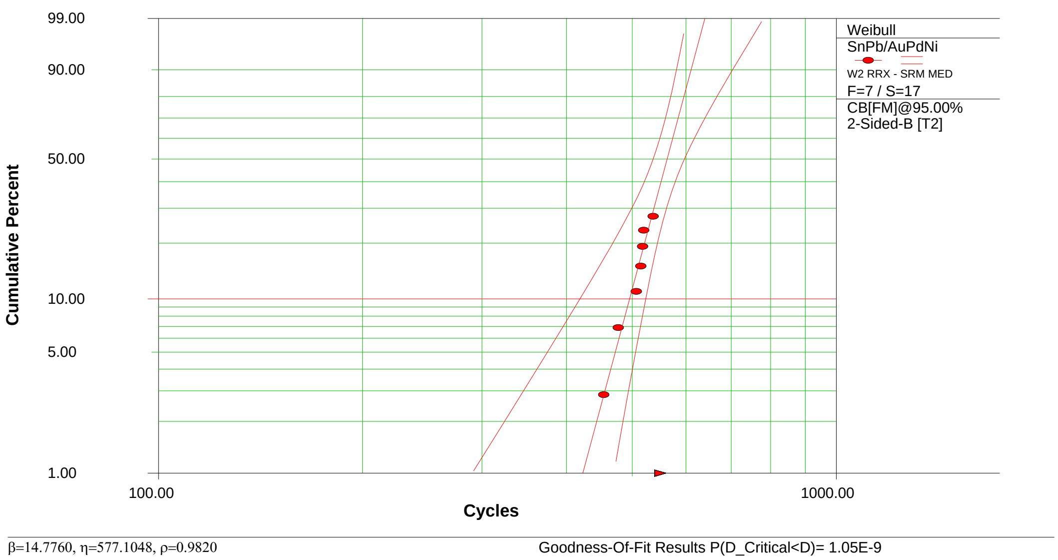

Figure 34 Weibull Plot of Gold-Palladium-Nickel TQFP-208 with Tin-Lead Solder Paste on Manufacture Test Vehicles (less outlier)

The Weibull plots for the different solder alloys were combined to facilitate comparative analysis. Figure 35 contains Weibull plots of tin-silver-copper and tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components compared to tin-lead soldered gold-palladium-nickel TQFP-208 components (with the outlier excluded). Figure 36 contains Weibull plots of tin-silver-copper and tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components compared to tin-lead soldered gold-palladium-nickel TQFP-208 components with the outlier included. There is not a sufficient sample size in which to draw statistically sound comparisons in solder alloy performance.

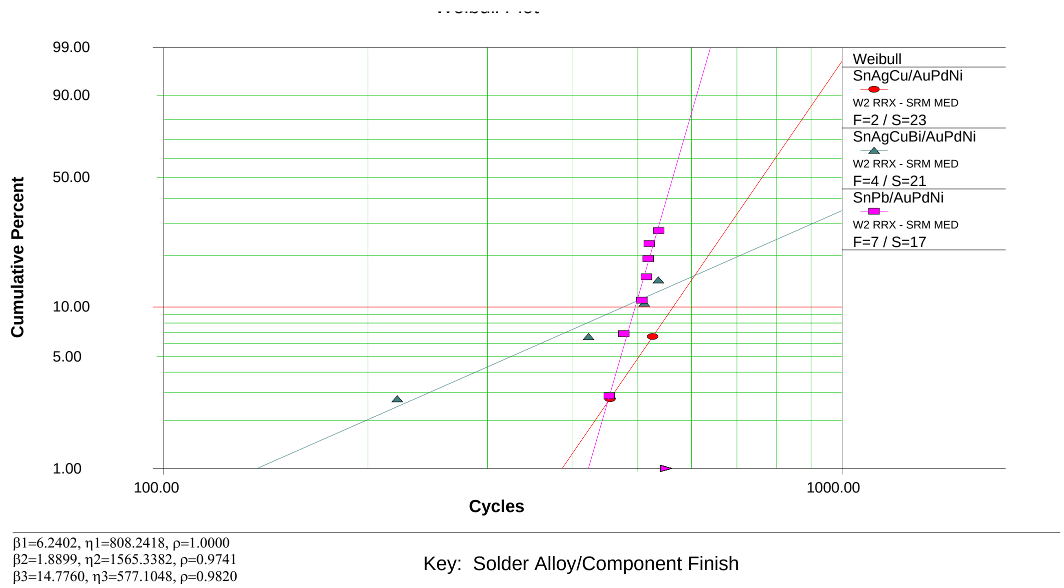

Figure 35 Weibull Plots of Gold-Palladium-Nickel TQFP-208 on Manufacture Test Vehicles (less outlier)

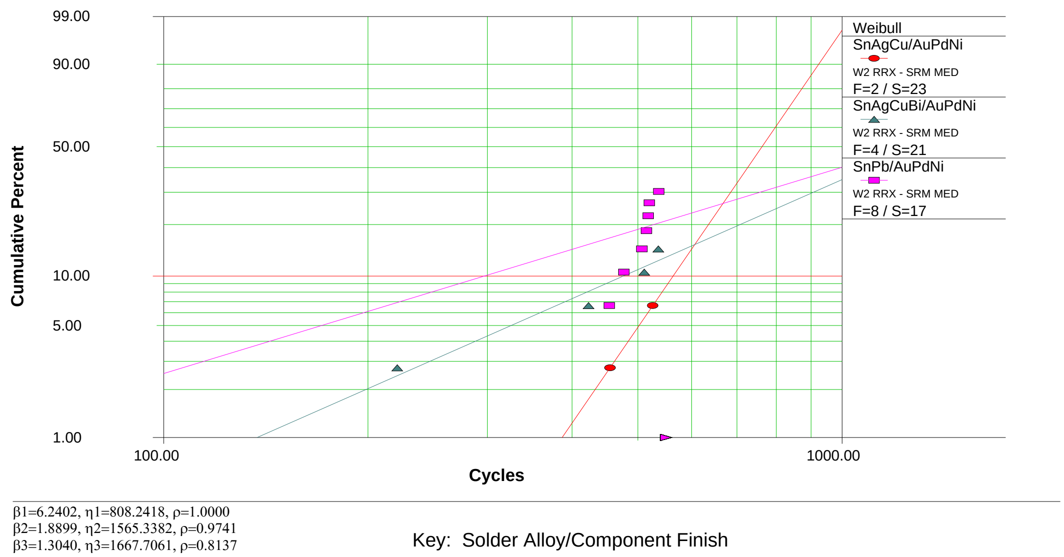

Figure 36 Weibull Plots of Gold-Palladium-Nickel TQFP-208 on Manufacture Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for TQFP-208 components on manufacture test vehicles:

- The probability that tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than tin-silver-copper soldered gold-palladium-nickel TQFP-208 components is 70%.
- The probability that tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components is 50%. Both data sets appear to be from the same population.

Therefore, tin-silver-copper-bismuth and tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than tin-silver-copper soldered gold-palladium-nickel TQFP-208 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the TQFP-208 components are tabulated in Table 6. The N(10%) data are graphically presented in Figure 37. There are not a sufficient number of samples that failed in which to draw statistically sound comparisons in solder alloy performance.

Table 6 Number of Cycles to 1, 10 and 63 Percent Failures for TQFP-208 on Manufacture Test Vehicles

Solder Paste	Lead Finish	N(1%)	N(10%)	N(63%)
SnAgCu	AuPdNi	387	564	808
SnAgCuBi	AuPdNi	137	476	1565
SnPb	AuPdNi	49	297	1667
SnPb (less outlier)	AuPdNi	423	496	577

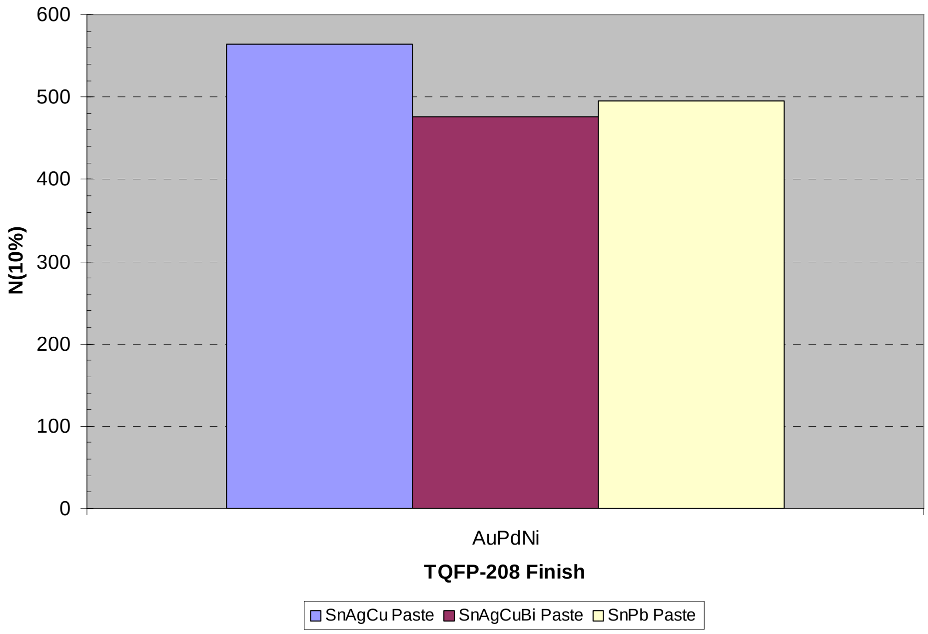

Figure 37 Chart of Number of Cycles to 10% Cumulative Failures by Solder Paste for TQFP-208 on Manufacture Test Vehicles

TSOP-50 Results and Discussion

The Weibull plot for tin-silver-copper soldered tin-copper TSOP-50 components is shown in Figure 38. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a fair fit of the data since two data points are on the 95-percent confidence limits and the goodness-of-fit result is near 0.5. There appears to be a "stairstep" in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data correspond to the step increases in the vibration levels that occurred as part of the test plan. Other project members have reported observing this stairstep on other studies involving only thermal cycling.

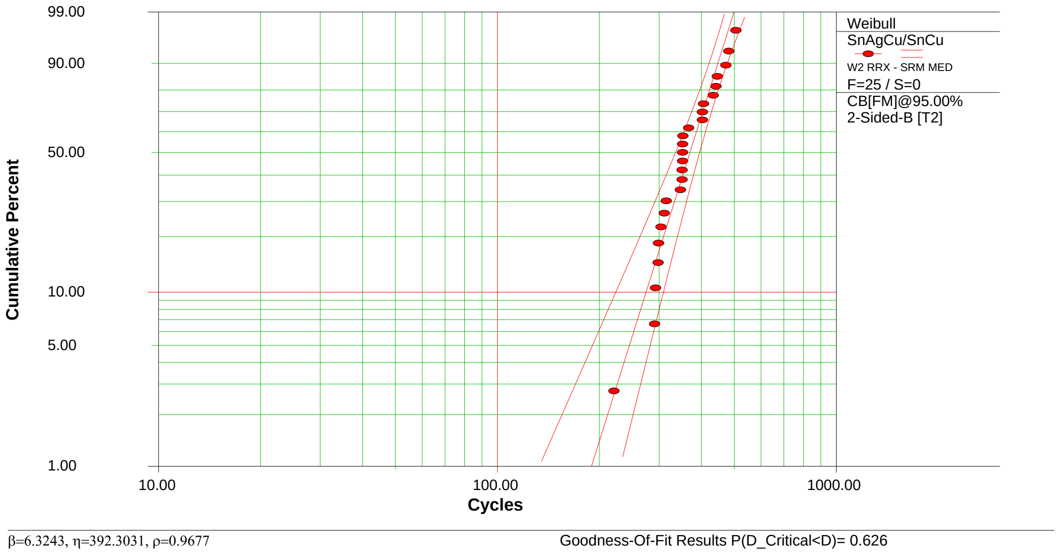

Figure 38 Weibull Plot of Tin-Copper TSOP-50 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper soldered tin-lead TSOP-50 components is shown in Figure 39. The 2-parameter Weibull regression is a poor fit of the data since many of the data exceed the 95-percent confidence limits and the goodness-of-fit result near one.

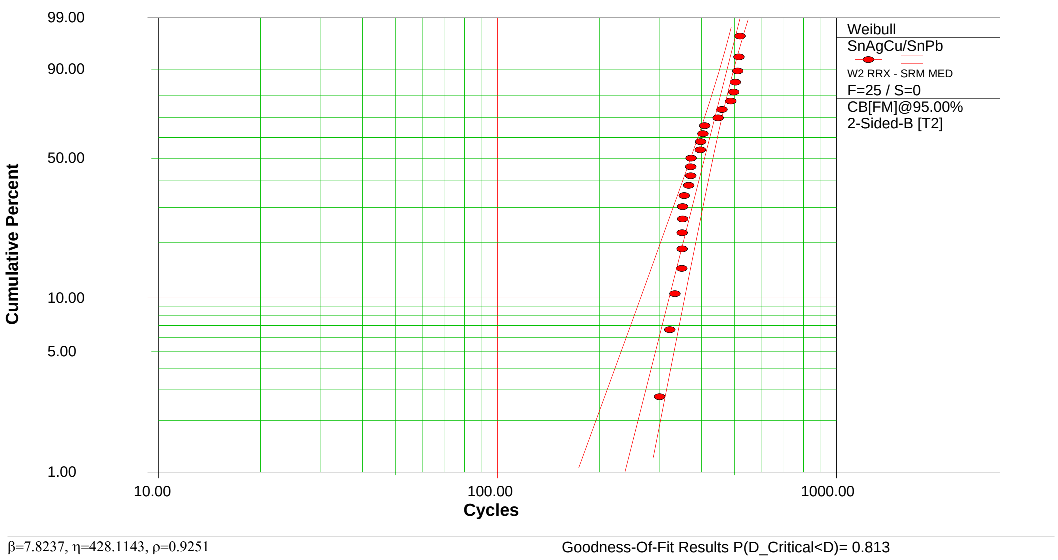

Figure 39 Weibull Plot of Tin-Lead TSOP-50 with Tin-Silver-Copper Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-copper TSOP-50 components is shown in Figure 40. Only 36-percent of these components failed. Therefore, there may not be a sufficient sample size to constitute a sound statistical sample.

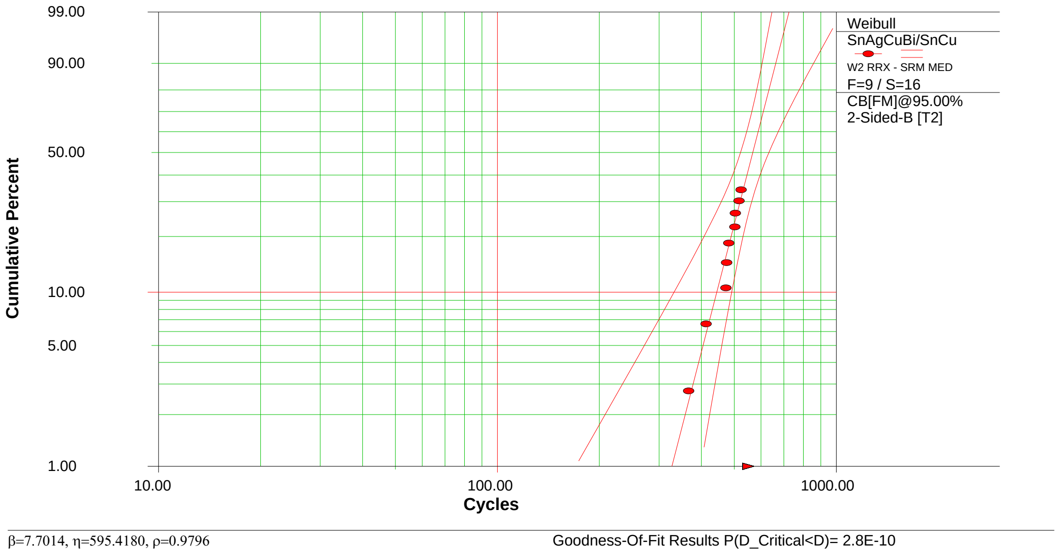

Figure 40 Weibull Plot of Tin-Copper TSOP-50 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-lead TSOP-50 components is shown in Figure 41. The 2-parameter Weibull regression is a good fit of the data since all of the data points are inside the 95-confidence limits and the goodness-of-fit result is near zero. There appears to be a slight "stairstep" in the data with vertical jumps near the time where the vibration level increases occurred.

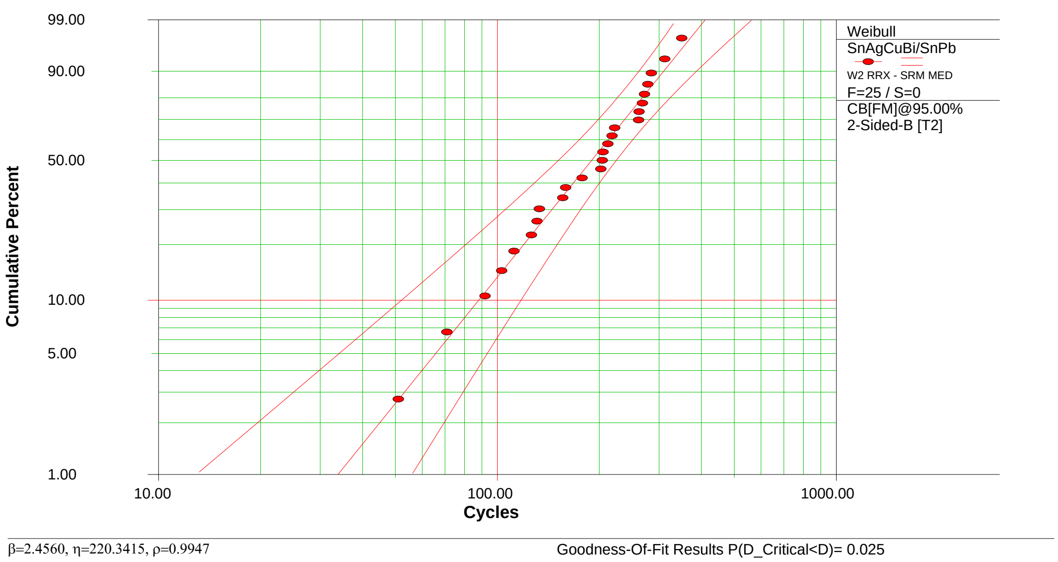

Figure 41 Weibull Plot of Tin-Lead TSOP-50 with Tin-Silver-Copper-Bismuth Solder Paste on Manufacture Test Vehicles

The Weibull plot for tin-lead soldered tin-lead TSOP-50 components is shown in Figure 42. The 2-parameter Weibull regression is a good fit of the data since few of the data fall outside the 95-percent confidence limits and the goodness-of-fit results is low. There appears to be a "stairstep" in the data with a prominent vertical jump at 500 cycles where a vibration level increase occurred.

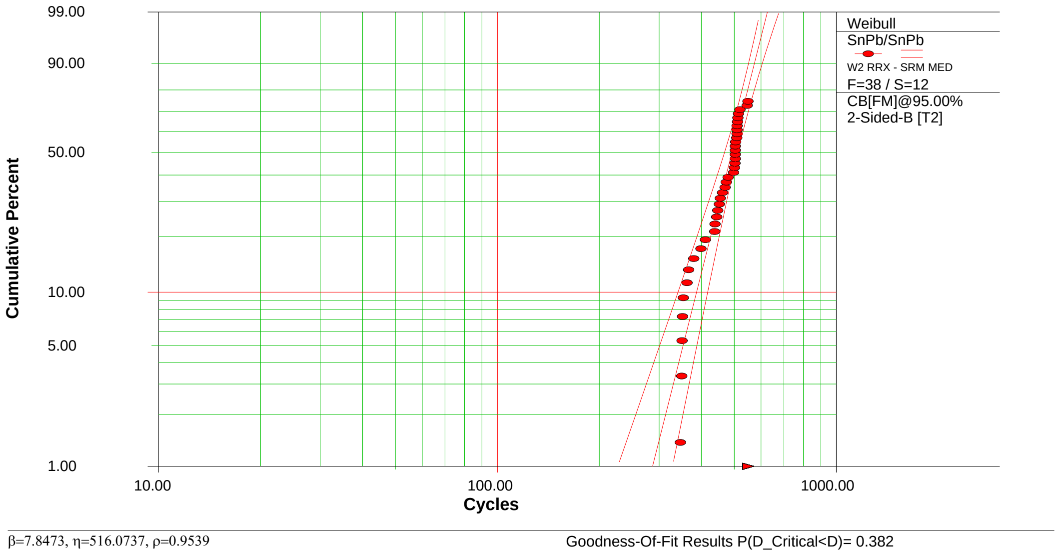

Figure 42 Weibull Plot of Tin-Lead TSOP-50 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Several of the Weibull plots in different lead finish and solder alloys combinations were generated to facilitate comparative analysis. Figure 43 contains Weibull plots of lead-free alloy soldered tin-copper TSOP-50 components compared to tin-lead soldered tin-lead TSOP-50 components. The plot shows tin-silver-copper-bismuth solder performed best with tin-lead solder ranked second and tin-silver-copper solder ranked last.

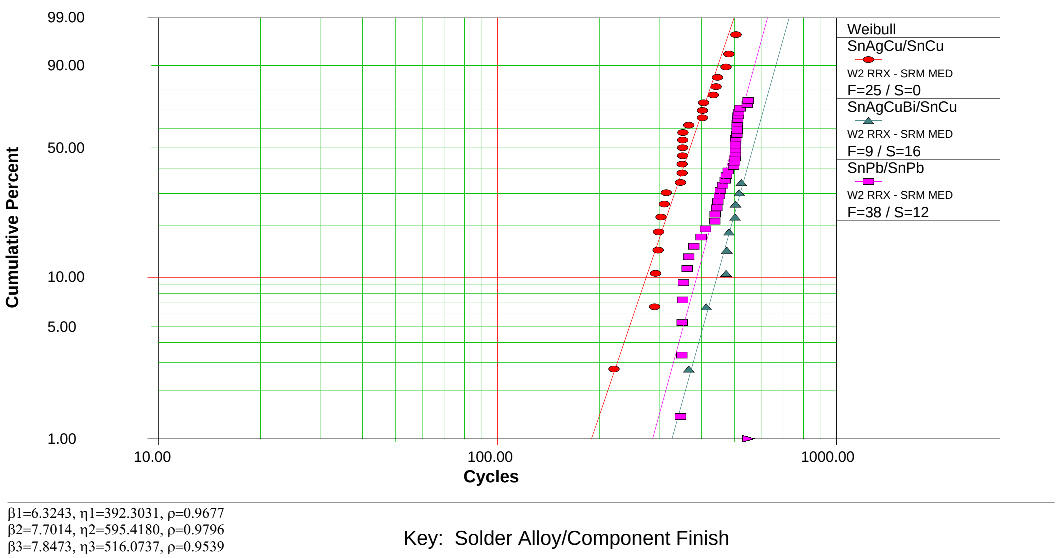

Figure 43 Weibull Plots of Tin-Copper TSOP-50 with Lead-Free Solder Pastes Compared to Tin-Lead TSOP-50 with Tin-Lead Solder Paste on Manufacture Test Vehicles

Figure 44 combines Weibull plots of tin-lead TSOP-50 components soldered with lead-free solders compared to tin-lead soldered tin-lead TSOP-50 components. The plot shows tin-lead solder performed the best with tin-silver-copper ranked second and tin-silver-copper-bismuth ranked last.

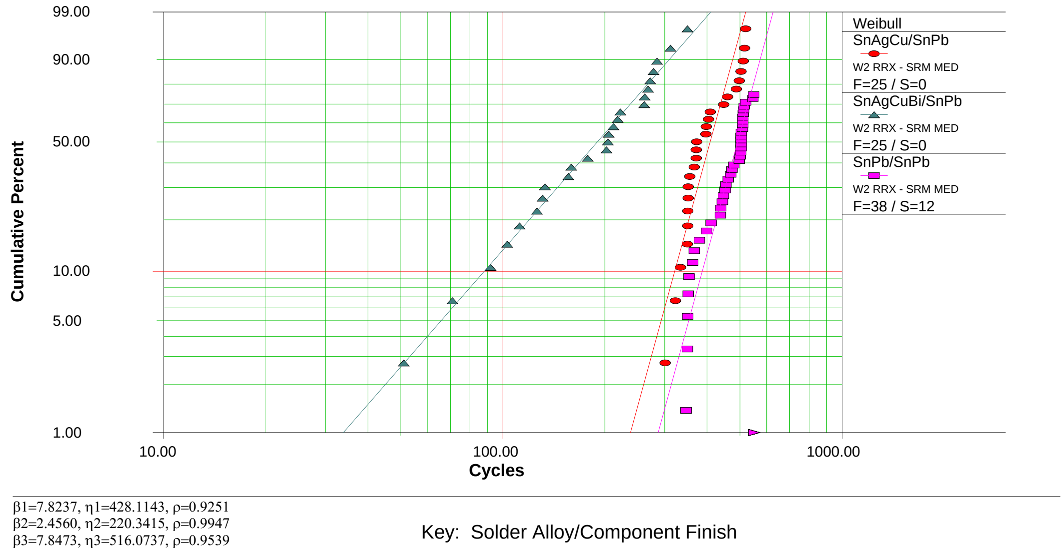

Figure 44 Weibull Plots of Tin-Lead TSOP-50 on Manufacture Test Vehicles

Figure 45 contains the Weibull plots for all of the combinations of component finish and solder alloy for the TSOP-50 components on the manufacture test vehicles. Overall, the tin-silver-copper-bismuth soldered tin-copper TSOP-50 components performed better than tin-lead soldered tin-lead TSOP-50 components. Tin-silver-copper soldered tin-lead TSOP-50 performed better than tin-silver-copper soldered tin-copper TSOP-50 components. While the tin-lead finish on the TSOP-50 appears to dramatically degrade the solder joint reliability when soldered with tin-silver-copper-bismuth solder, the tin-lead finish appears to slightly improve the reliability with tin-silver-copper solder.

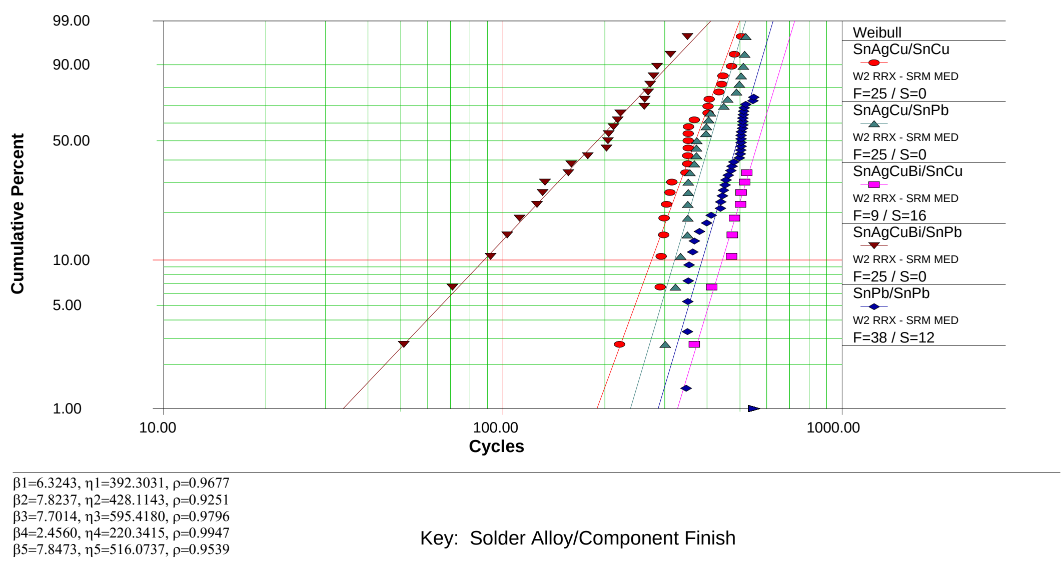

Figure 45 Weibull Plots of TSOP-50 on Manufacture Test Vehicles

This phenomenon is similar with the observation made on the CLCC-20 components. However, the degradation of tin-silver-copper-bismuth solder joint reliability due to tin-lead component finish appears to be inversely proportional to the amount of tin-lead finish on the component. The amount of tin-lead on the CLCC-20 component is much greater than the amount of tin-lead on the tin-lead TSOP-50 components relative to the resulting solder joint. This effect should be further investigated with destructive physical analysis of the tin-silver-copper-bismuth soldered tin-lead CLCC-20 and TSOP-50 components. Microsection analysis may reveal a bismuth-lead or other intermetallic compound that is formed in the presence of lower lead contamination levels and that reduces the overall solder joint reliability.

Based on the results of the Weibull++6 Tests of Comparison tool for TSOP-50 components on manufacture test vehicles:

- The probability that tin-lead soldered tin-lead TSOP-50 components will last longer than tin-silver-copper soldered tin-copper TSOP-50 components is 89%.
- The probability that tin-lead soldered tin-lead TSOP-50 components will last longer than tin-silver-copper soldered tin-lead TSOP-50 components is 81%.
- The probability that tin-lead soldered tin-lead TSOP-50 components will last longer than tin-silver-copper-bismuth soldered tin-copper TSOP-50 components is 25%.
- The probability that tin-lead soldered tin-lead TSOP-50 components will last longer than tin-silver-copper-bismuth soldered tin-lead TSOP-50 components is 99%.

Therefore, tin-silver-copper-bismuth soldered tin-copper TSOP-50 components will last longer than tin-lead soldered tin-lead TSOP-50 components. The tin-lead soldered tin-lead TSOP-50 components will last longer than the tin-silver-copper soldered tin-copper, tin-silver-copper soldered tin-lead and tin-silver-copper-bismuth soldered tin-lead TSOP-50 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various TSOP-50 component finishes and solder alloys are tabulated in Table 7 and graphically presented in Figure 46. Using the N(10%) value for the tin-lead soldered tin-lead TSOP-50 components as the baseline, the N(10%) value for tin-silver-copper-bismuth soldered tin-copper TSOP-50 components is greater than the baseline and therefore, meets the JTP acceptance criteria. The N(10%) values for tin-silver-copper soldered tin-copper, tin-silver-copper soldered tin-lead and tin-silver-copper-bismuth soldered tin-lead TSOP-50 components are less than the baseline and therefore, do not meet the JTP acceptance criteria.

Table 7 Number of Cycles to 1, 10 and 63 Percent Failures for TSOP-50 on Manufacture Test Vehicles

Solder Paste	Lead Finish	N(1%)	N(10%)	N(63%)
SnAgCu	SnCu	190	275	392
SnAgCu	SnPb	238	321	428
SnAgCuBi	SnCu	328	445	595
SnAgCuBi	SnPb	34	88	220
SnPb	SnPb	287	387	516

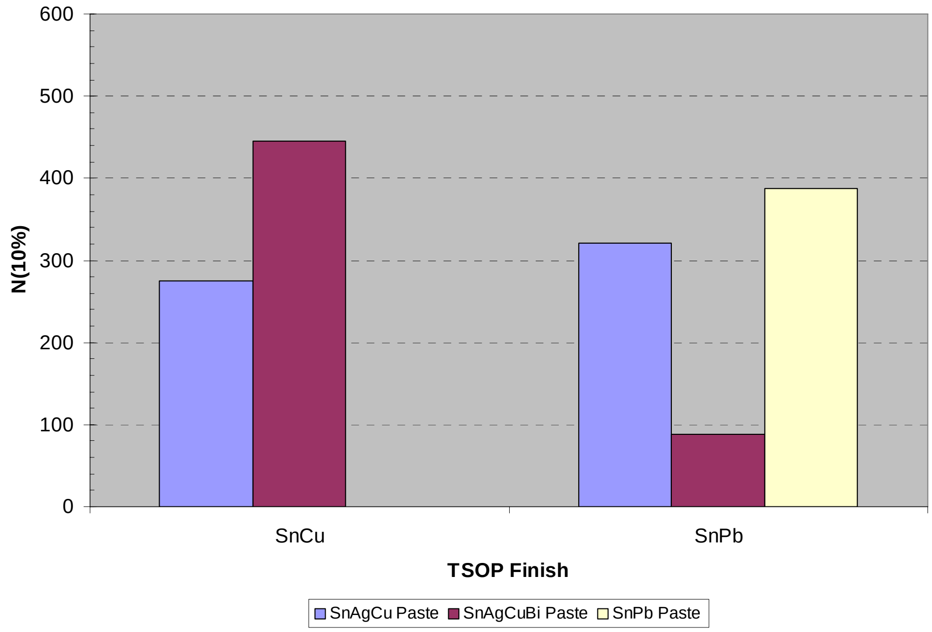

Figure 46 Chart of Number of Cycles to 10% Cumulative Failures by Solder Paste and Lead Finish for TSOP on Manufacture Test Vehicles

The effect of tin-lead contamination on the tin-silver-copper soldered TSOP-50 components is shown in Figure 47. The presence of tin-lead appears to slightly improve the reliability of the tin-silver-copper solder joint.

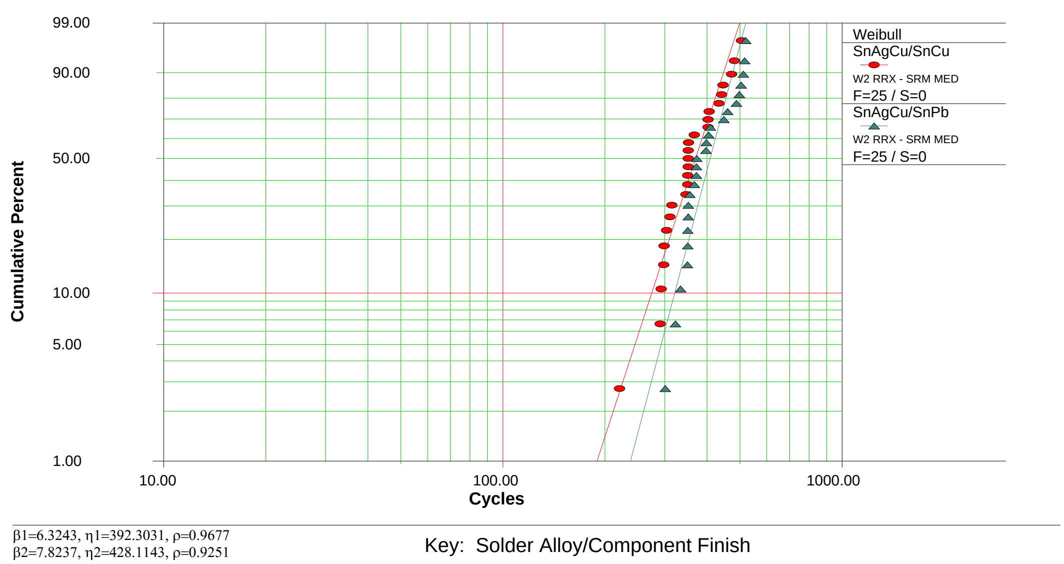

Figure 47 Effect of Tin-Lead Contamination of Tin-Silver-Copper Soldered TSOP-50 on Manufacture Test Vehicles

The effect of tin-lead contamination on the tin-silver-copper-bismuth soldered TSOP-50 components is shown in Figure 48. The presence of tin-lead appears to severely degrade the reliability of the tin-silver-copper-bismuth solder joint.

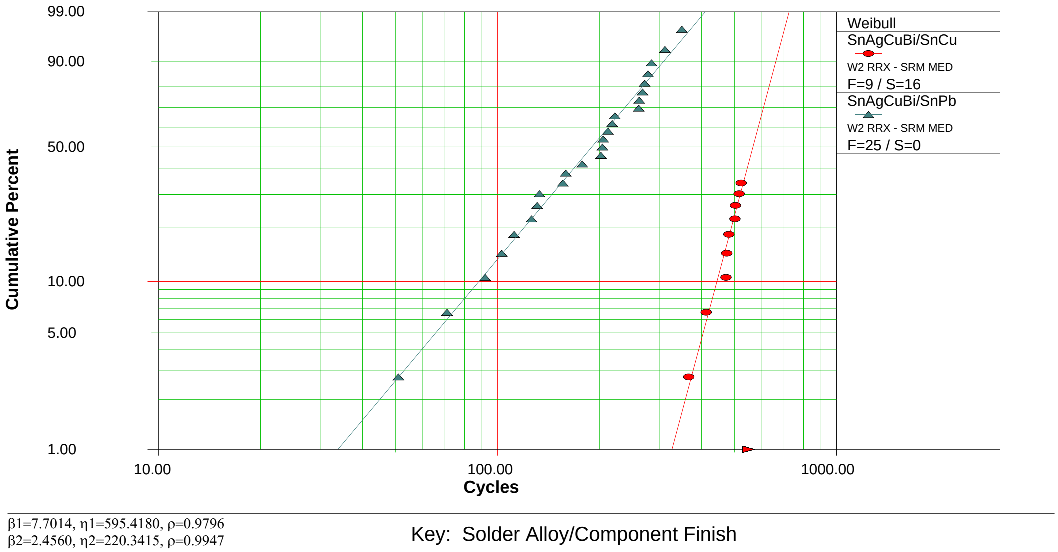

Figure 48 Effect of Tin-Lead Contamination on Tin-Silver-Copper-Bismuth Soldered TSOP-50 on Manufacture Test Vehicles

Rework Test Vehicle Results and Discussion

The rework test vehicles were tested for 550 cycles. The HALT chamber experienced an over temperature condition during cycle 537. The failure data were truncated at 536 cycles. The raw data are tabulated in Table 22 starting on page 97. Detected solder joint failures at ten cycles or lower were excluded from analysis by team consensus. The team felt these early life failures were due to manufacturing or testing anomalies and the data should be excluded to prevent skewing the test results. The rework vehicles were inspected for lead damage or broken wires. One wire was noted as broken on a rework test vehicle and the datum was excluded. Due to the over temperature condition, a larger number of components were missing from the test vehicles at the conclusion of the test than was experienced with the manufacture test vehicles.

The data were compiled by assembly serial number, component type and component finish and tabulated in Table 8. Test vehicle 45 experienced a lower number of total failures compared to the other test vehicles. This suggests test vehicle 45 may have experienced lower thermal and/or vibration stresses during the testing.

Table 8 Number of Failed Components by Rework Test Vehicle

Component & Finish	Test Vehicle Serial Number															Total
	45	66	67	68	70	172	173	174	175	176	200	201	202	203	204	
BGA SnAgCu						8	8	8	8	8	8	8	8	8	8	**80**
BGA SnPb	7	8	8	8	8											**36**
Reworked BGA	1	2	2	2	2	2	2	2	1	2	2	2	2	2	1	**27**
CLCC SnAgCu						10	10	10	10	10						**50**
CLCC SnAgCuBi											10	10	10	10	10	**50**
CLCC SnPb	10	10	10	10	10											**50**
PDIP AuPdNi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
PDIP Sn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Reworked PDIP	0	0	0	0	1	1	1	2	1	2	0	1	0	0	1	**10**
PLCC Sn	0	0	0	0	0	0	1	1	0	0	0	2	0	1	0	**5**
TQFP-144 Sn	1	1	4	1	5	3	4	3	3	5	2	5	4	3	2	**46**
TQFP-208 AuPdNi	0	1	0	1	3	1	3	3	1	3	2	3	1	2	1	**25**
Reworked TQFP-208	1	2	2	2	2	1	2	2	1	2	2	2	2	2	2	**27**
TSOP SnCu						8	8	8	8	8	8	8	8	8	8	**80**
TSOP SnPb	7	8	8	8	8											**39**
Reworked TSOP	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	**30**
PTH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
TOTAL	**29**	**34**	**36**	**34**	**41**	**36**	**41**	**41**	**35**	**42**	**36**	**43**	**37**	**38**	**35**	**558**

The data were also segregated by component type, component finish and solder alloy and tabulated in Table 9. Test vehicles reworked with tin-lead solder had the best performance with 74 percent of the reworked components registering as a failure. Test vehicles reworked with tin-silver-copper had the next best performance with 86 percent of the reworked components registering as a failure. Test vehicles reworked with tin-silver-copper-bismuth solder had the most solder joints fail at 100 percent of the reworked components registering as a failure.

In general, reworked components failed more often than the unreworked components. The exception to this trend was the reworked BGA-225 components. Use of the hot air rework station may have exposed the BGA-225 components to hotter temperatures than they experienced during the original reflow solder process. The higher temperatures may have provided better solder melting and improved the solder joint reliability.

Table 9 Number of Failed Components by Component, Component Finish, Rework Status and Solder Alloy on Rework Test Vehicles

Component & Finish	No Rework	SAC Rework	SACB Rework	SnCu Rework	SnPb Rework
BGA SnAgCu	100% (80 of 80)	90% (18 of 20)			
BGA SnPb	98% (39 of 40)				90% (9 of 10)
CLCC SnAgCu	100% (50 of 50)				
CLCC SnAgCuBi	100% (50 of 50)				
CLCC SnPb	100% (50 of 50)				
PDIP AuPdNi	0% (0 of 43)	70% (7 of 10)		22% (2 of 9)	20% (1 of 5)
PDIP Sn	0% (0 of 75)				0% (0 of 4)
PLCC Sn	7% (5 of 74)				
TQFP-144 Sn	61% (46 of 75)				
TQFP-208 AuPdNi	56% (25 of 45)	80% (8 of 10)	100% (10 of 10)		90% (9 of 10)
TSOP SnCu	100% (80 of 80)	100% (10 of 10)	100% (10 of 10)		
TSOP SnPb	98% (39 of 40)				100% (10 of 10)
PTH	0% (0 of 15)				
Grand Total	**65% (464 of 715)**	**86% (43 of 50)**	**100% (20 of 20)**	**22% (2 of 9)**	**74% (29 of 39)**

The plated-through-holes, PLCC-20 and PDIP-20 experienced little or no failures. No additional data analysis was conducted on these components. The failed component data were analyzed by rework status, component type, component finish and solder alloy using ReliaSoft Weibull++6 software. First, the data were analyzed using 2-parameter Weibull analysis. The Weibull analysis included a goodness-of-fit test. The goodness-of-fit test returns the probability that the respective Critical Value is less than the Value Calculated. High values, close to one, indicate that there is a significant difference between the theoretical distribution and this data set. Next, the lead-free solder joint reliability was compared to the baseline tin-lead solder joint reliability using the Weibull++6 Tests of

Comparison tool. The tool reported the probability of the tin-lead controls lasting longer than the lead-free test case. Finally, the number of cycles to reach ten-percent cumulative failures was determined from the Weibull analysis using the Weibull++6 software. The following sections provide the Weibull analysis for each component type.

BGA-225 Results and Discussion

The Weibull plot for unreworked tin-silver-copper BGA-225 components soldered with tin-lead solder is shown in Figure 49. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right of the chart indicates the solder alloy then component finish. The 2-parameter Weibull plot is a good fit of the data since the data points resides within the confidence limits and the goodness-of-fit result is low.

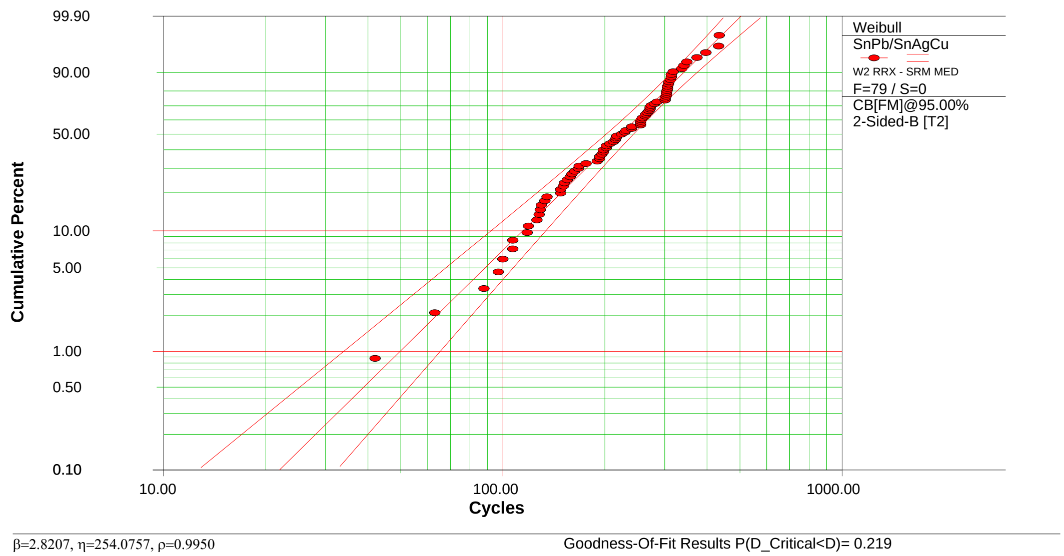

Figure 49 Weibull Plot of Tin-Silver-Copper BGA-225 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for unreworked tin-lead BGA-225 components soldered with tin-lead solder is shown is Figure 50. The 2-parameter Weibull plot is a good fit of the data since all of the data fit inside the 95-percent confidence limits and the goodness-of-fit result is relatively low.

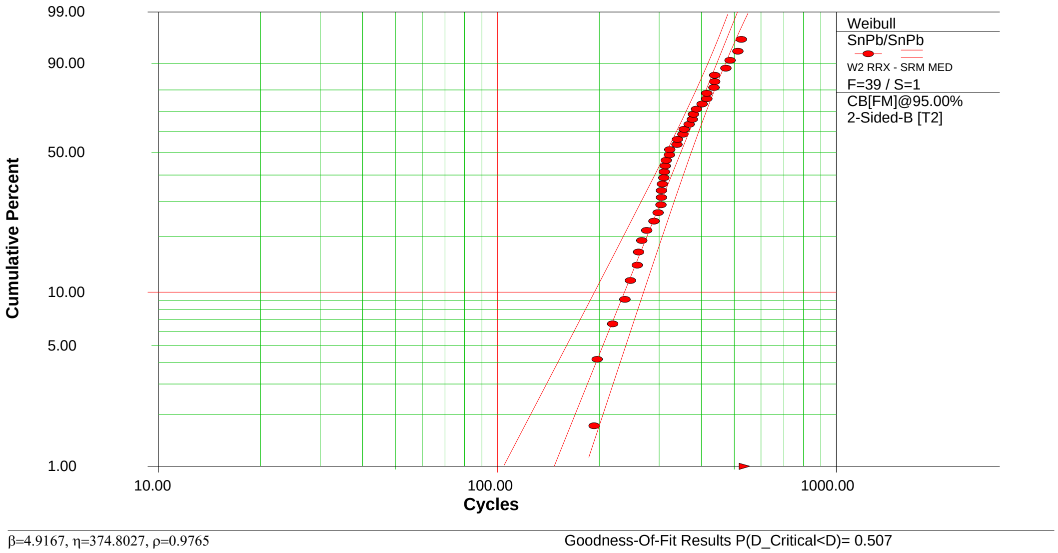

Figure 50 Weibull Plot of Tin-Lead BGA-225 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for reworked tin-silver-copper BGA-225 components is shown in Figure 51. The 2-parameter Weibull plot is a fair fit of the data since some data are outside the 95-percent confidence limits and the goodness-of-fit result is near one-half. There appears to be a “stairstep” in the data.

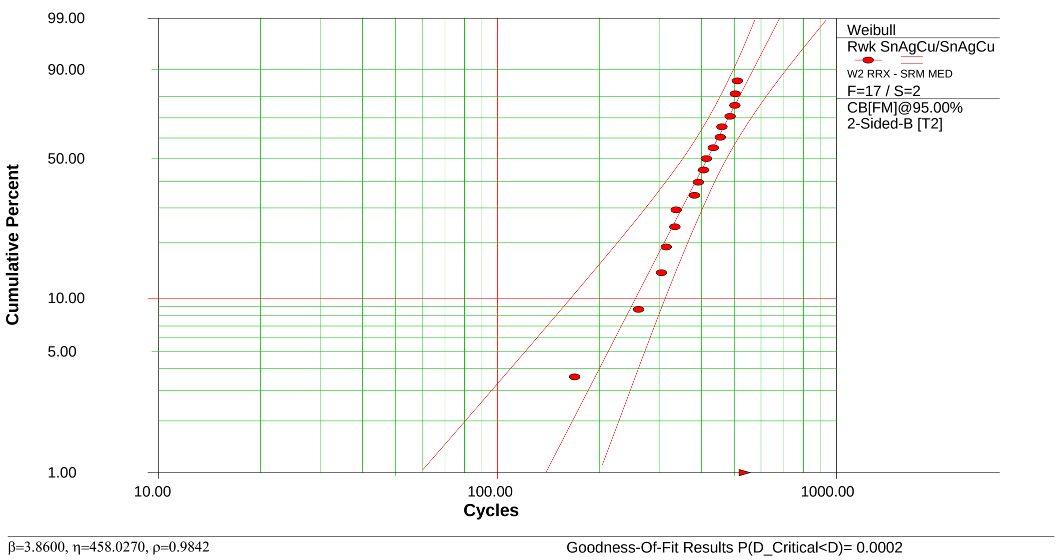

Figure 51 Weibull Plot of Reworked Tin-Silver-Copper BGA-225 on Rework Test Vehicles

The Weibull plot for reworked tin-lead BGA-225 components is shown is Figure 52. The 95-percent confidence limits could not be computed for this data. The 2-parameter Weibull plot is a good fit of the data since the goodness-of-fit result is low.

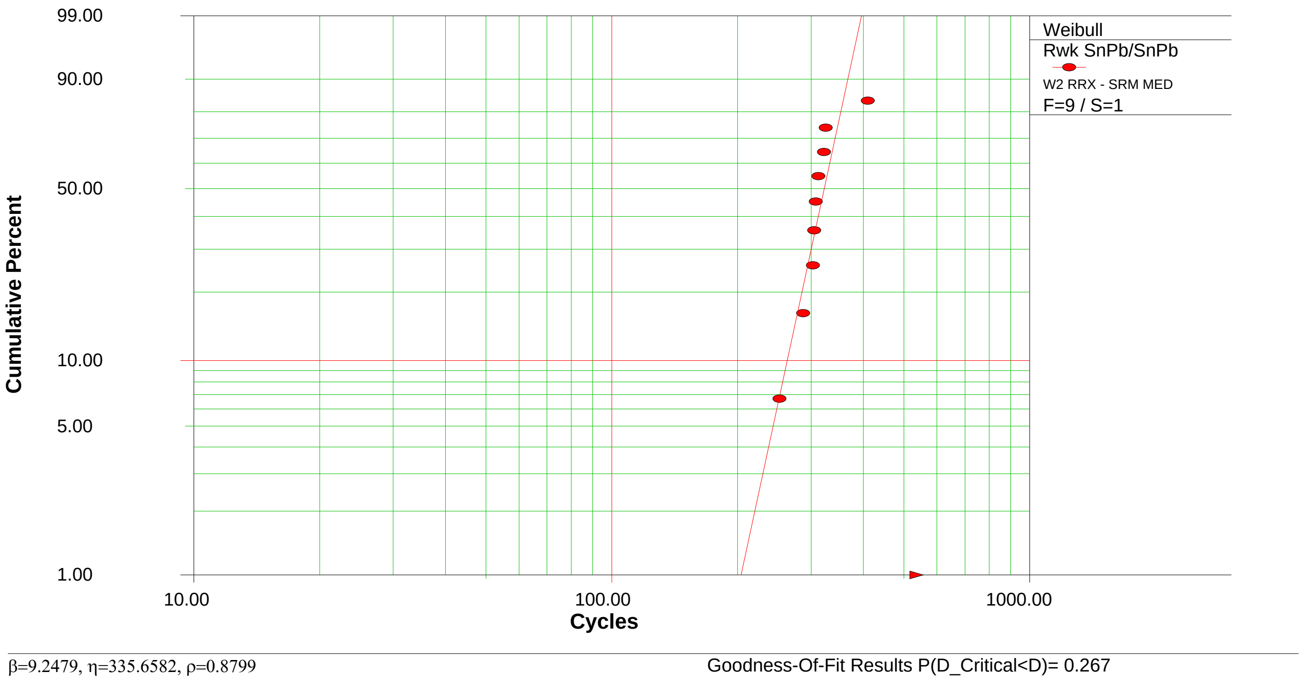

Figure 52 Weibull Plot of Reworked Tin-Lead BGA-225 on Rework Test Vehicles

Several of the Weibull plots were combined to facilitate comparative analysis. Figure 53 contains Weibull plots of reworked tin-silver-copper BGA-225 components compared to reworked tin-lead BGA-225 components. The plot shows both samples had performed equally as well.

Figure 54 combines Weibull plots of unreworked tin-lead soldered tin-silver-copper BGA-225 components compared to unreworked tin-lead soldered tin-lead BGA-225 components. The plot shows tin-lead soldered tin-lead BGA-225 components perform better than the tin-lead soldered tin-silver-copper BGA-225 components. The use of a tin-lead solder profile during the solder reflow process may have been insufficient to cause the tin-silver-copper ball on the BGA-225 components to properly fuse with the tin-lead solder paste.

Figure 55 contains the Weibull plots for all of the combinations of rework status, component finish and solder alloy for the BGA-225 components on the rework test vehicles.

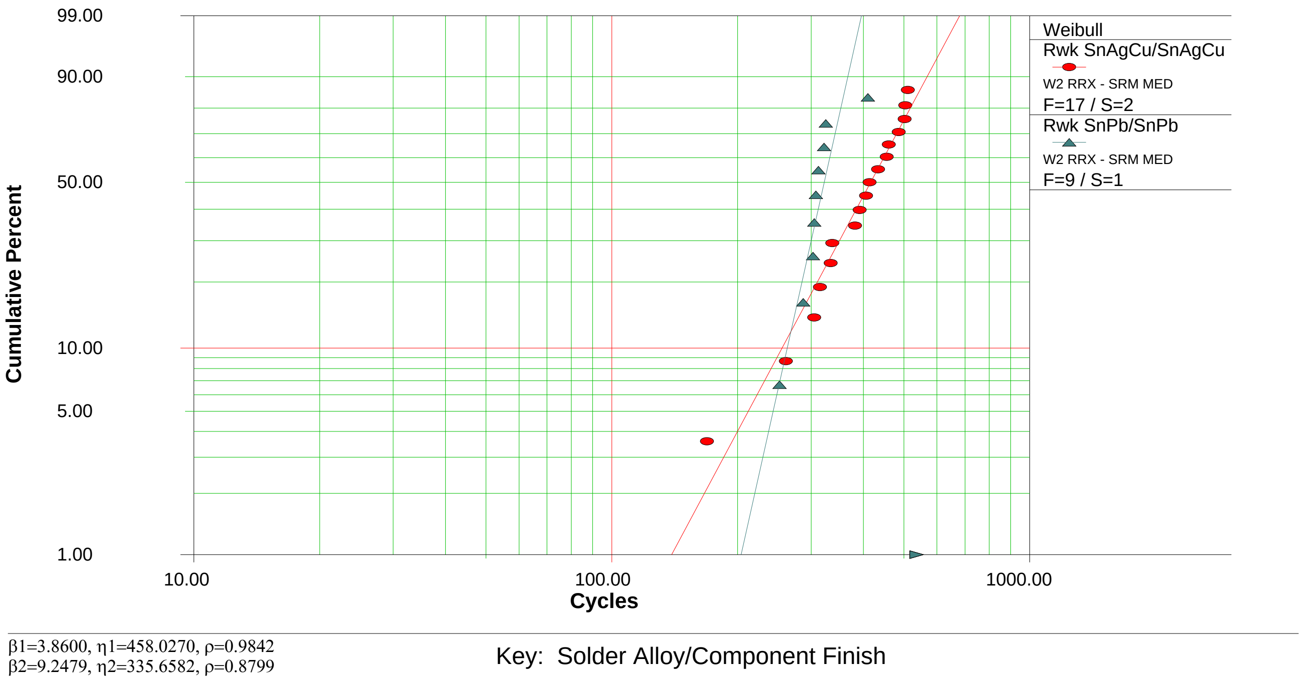

Figure 53 Weibull Plots of Reworked BGA-225 on Rework Test Vehicles

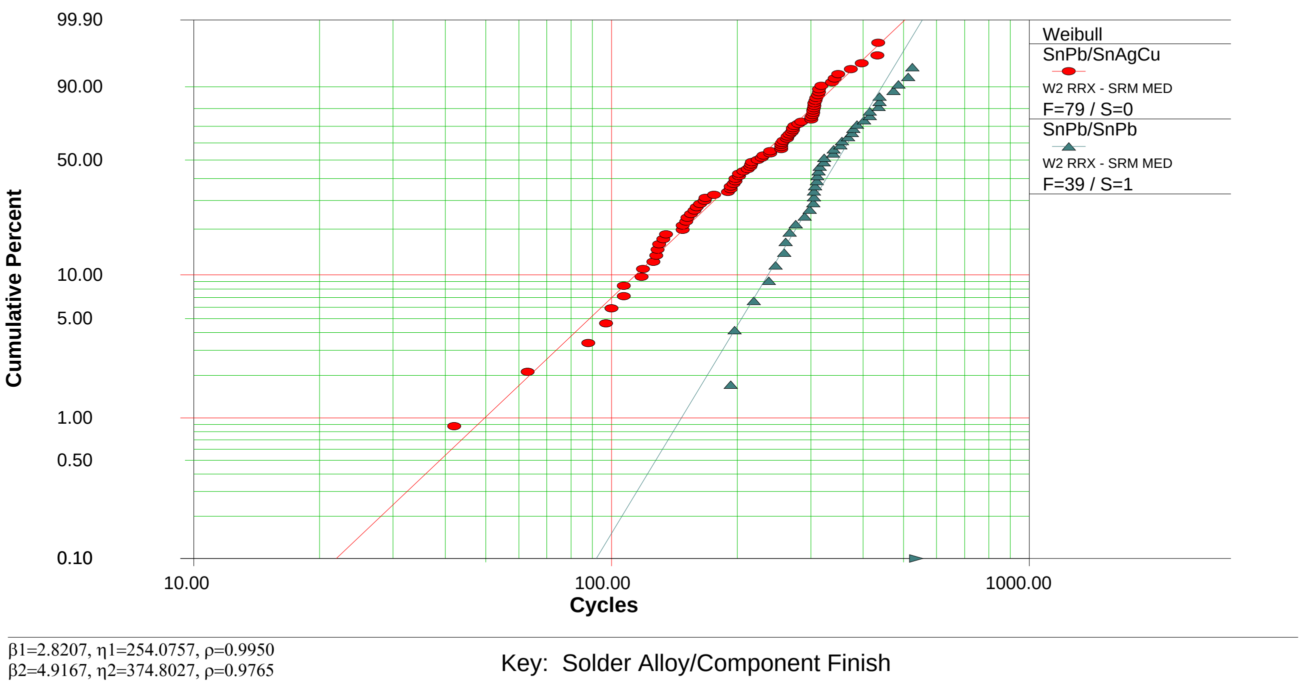

Figure 54 Weibull Plots of Unreworked BGA-225 on Rework Test Vehicles

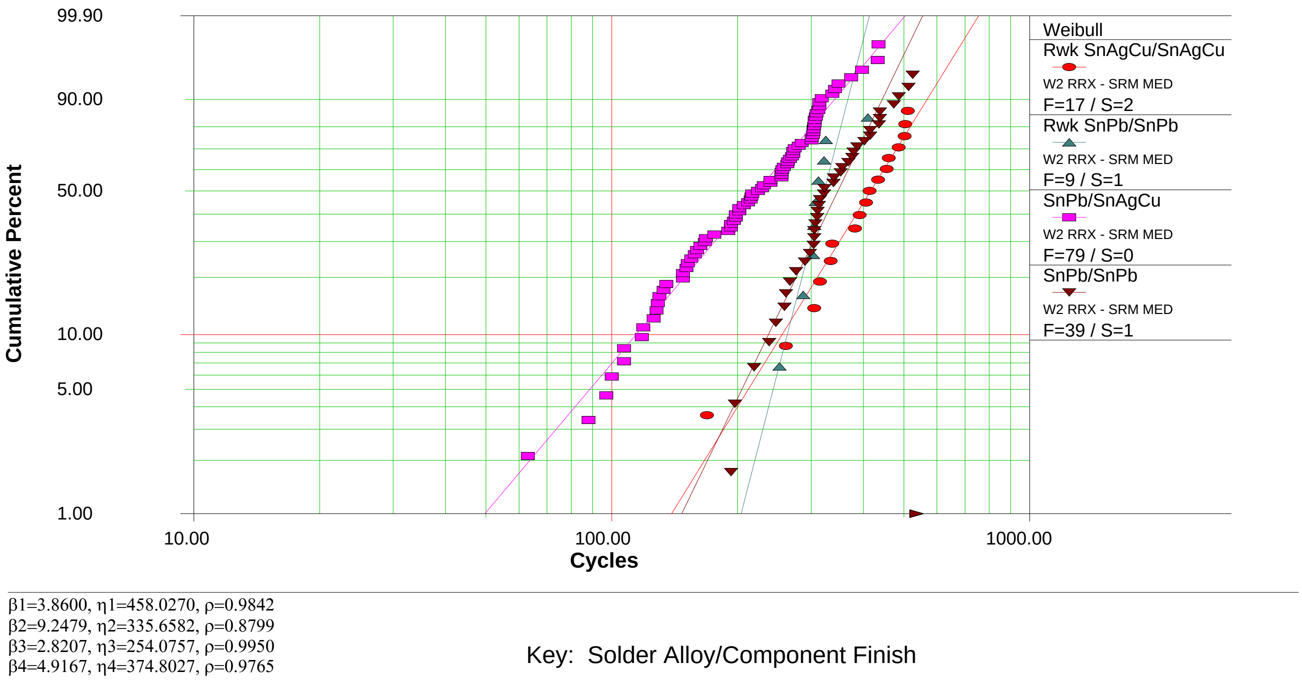

Figure 55 Weibull Plots of BGA-225 on Rework Test Vehicle

Based on the results of the Weibull++6 Tests of Comparison tool for BGA-225 components on rework test vehicles:

- The probability that reworked tin-lead BGA-225 components will last longer than reworked tin-silver-copper BGA-225 components is 23%.
- The probability that unreworked tin-lead soldered tin-lead BGA-225 components will last longer than unreworked tin-lead soldered tin-silver-copper BGA-225 components is 84%.
- The probability that reworked tin-lead BGA-225 components will last longer than unreworked tin-lead soldered tin-lead BGA-225 components is 38%.

Therefore, the tests of comparison results show reworked tin-silver-copper BGA-225 components will last longer than reworked tin-lead BGA-225 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various BGA component finishes and solder alloys are tabulated in Table 3. The N(10%) data are graphically presented in Figure 12. Using the N(10%) value for reworked tin-lead BGA-225 components as the baseline, the N(10%) value for the reworked tin-silver-copper BGA-225 components is less than baseline and therefore <u>does not meet</u> the JTP acceptance criteria. This result is reversed if the N(63%) values are used as the basis for the comparison. Reworked tin-silver-copper BGA-225 components <u>meet</u> the acceptance criteria if the N(63%) values are used for comparison.

Table 10 Number of Cycles to 1, 10 and 63 Percent Failures for BGA-225 on Rework Test Vehicles

Condition	Solder Paste	BGA Ball	N(1%)	N(10%)	N(63%)
No Rework	SnPb	SnAgCu	50	114	254
No Rework	SnPb	SnPb	147	237	375
Reworked	none	SnAgCu	139	256	458
Reworked	none	SnPb	204	263	336

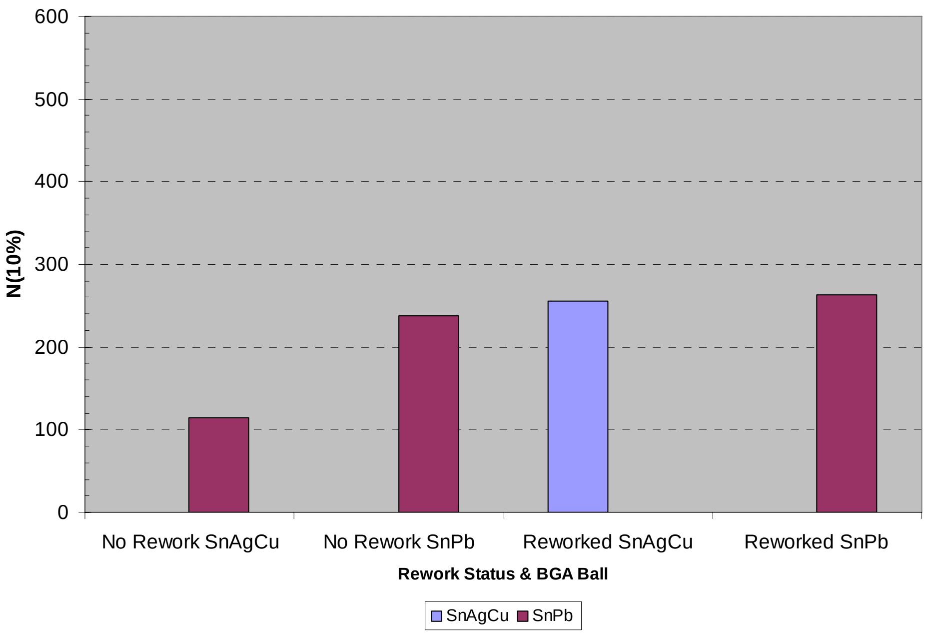

Figure 56 Chart of Number of Cycles to 10% Cumulative Failures for BGA-225 on Rework Test Vehicles

CLCC-20 Results and Discussion

As part of the test plan, none of the CLCC-20 components were reworked. All of the CLCC-20 components were soldered with tin-lead solder paste. The Weibull plot for tin-lead soldered tin-silver-copper CLCC-20 components is shown in Figure 57. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a fair fit of the data since some data points are outside the 95-percent confidence limits and the goodness-of-fit result is low. There appears to be a “stairstep” in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data occur where step increases in the vibration levels occurred as part of the test plan.

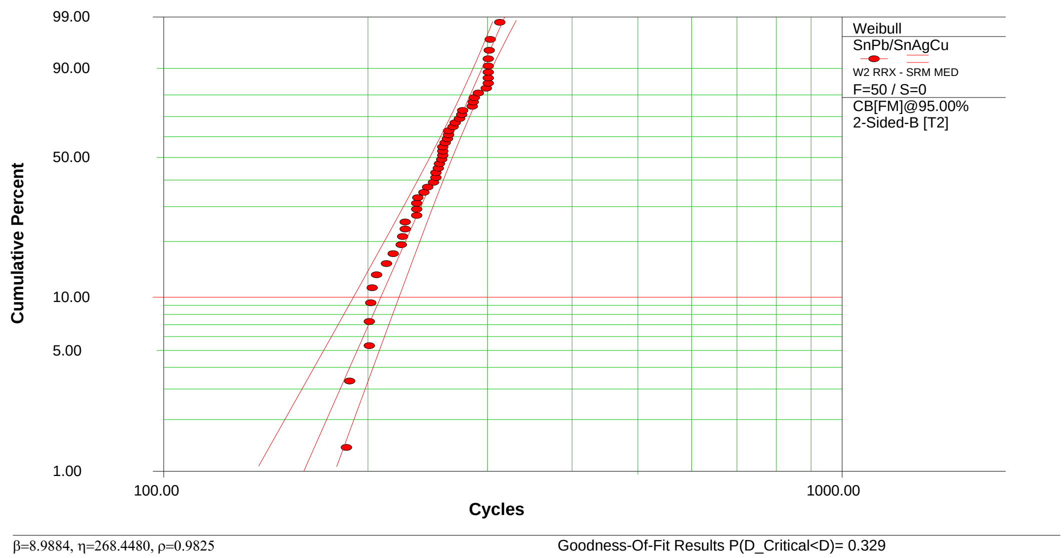

Figure 57 Weibull Plot of Tin-Silver-Copper CLCC-20 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for tin-lead soldered tin-silver-copper-bismuth CLCC-20 components is shown in Figure 58. The 2-parameter Weibull regression is a fair fit of the data since some data exceed the 95-percent confidence limits and the goodness-of-fit result is near 0.5. There appears to be a "stairstep" in the data with vertical jumps near the time where the vibration level increases occurred.

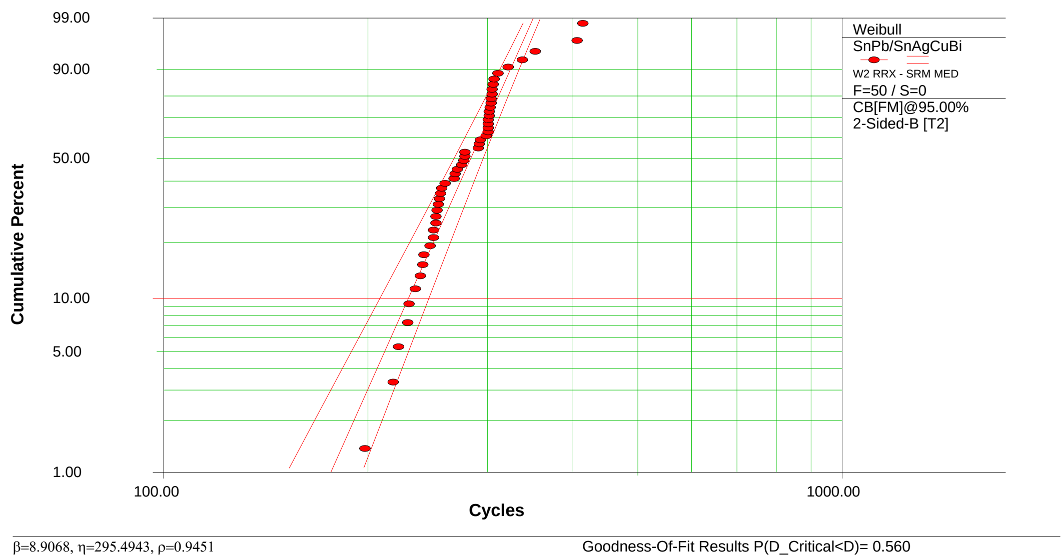

Figure 58 Weibull Plot of Tin-Silver-Copper-Bismuth CLCC-20 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for tin-lead soldered tin-lead CLCC-20 components is shown in Figure 59. The 2-parameter Weibull regression is a poor fit of the data since many of the data points are outside the 95-confidence limits and the goodness-of-fit result is near one. There appears to be a "stairstep" in the data with vertical jumps near the time where the vibration level increases occurred.

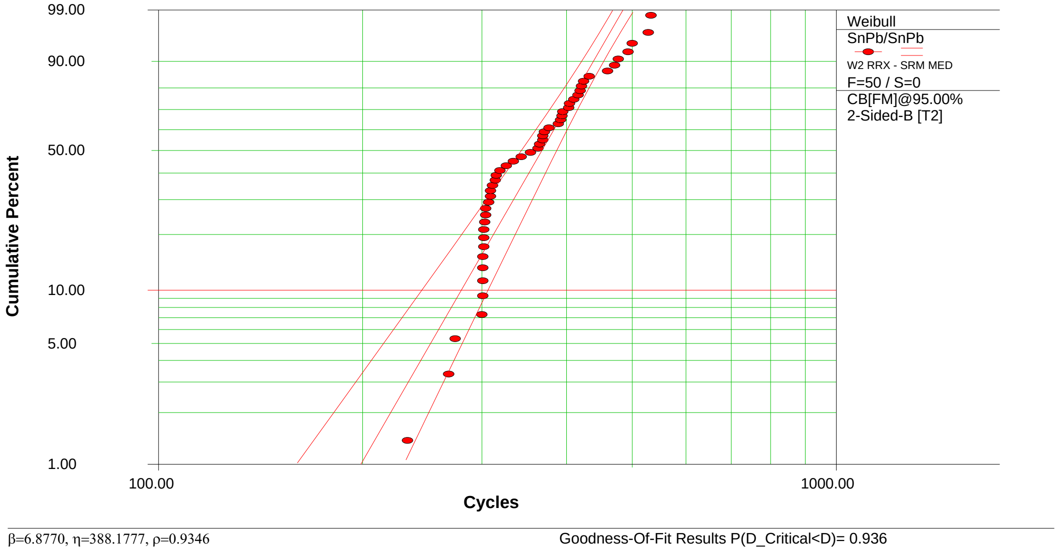

Figure 59 Weibull Plot of Tin-Lead CLCC-20 with Tin-Lead Paste on Rework Test Vehicles

The Weibull plots were combined to facilitate comparative analysis. Figure 60 contains Weibull plots of tin-lead soldered tin-silver-copper and tin-lead soldered tin-silver-copper-bismuth CLCC-20 components compared to tin-lead soldered tin-lead CLCC-20 components. The plot shows a clear delineation in solder joint reliability between the three samples. Tin-lead soldered tin-lead CLCC-20 components performed best with tin-lead soldered tin-silver-copper-bismuth CLCC-20 components second and tin-lead soldered tin-silver-copper CLCC-20 components last. The use of a tin-lead solder profile during the solder reflow process may have been insufficient to cause the tin-silver-copper and tin-silver-copper-bismuth lead finishes on the CLCC-20 components to properly fuse with the tin-lead solder paste. In addition, the large amount of lead contamination on the tin-silver-copper-bismuth tinned CLCC-20 components did not appear to degrade the solder joint reliability as much as the degradation with the tin-lead TSOP-50 components soldered with tin-silver-copper-bismuth on the manufacture test vehicles.

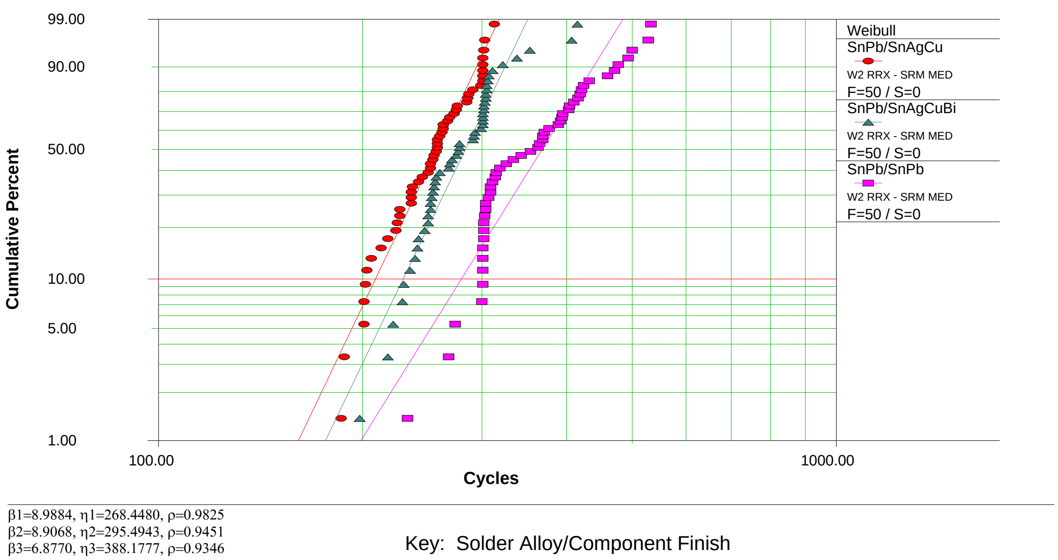

Figure 60 Weibull Plots of CLCC-20 on Rework Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for CLCC-20 components on rework test vehicles:

- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-lead soldered tin-silver-copper CLCC-20 components is 93%.
- The probability that tin-lead soldered tin-lead CLCC-20 components will last longer than tin-lead soldered tin-silver-copper-bismuth CLCC-20 components is 87%.

Therefore, tin-lead soldered tin-lead CLCC-20 components will last longer than tin-lead soldered tin-silver-copper-bismuth CLCC-20 components and tin-silver-copper-bismuth soldered tin-lead CLCC-20 components will last longer than tin-lead soldered tin-silver-copper CLCC-20 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various CLCC-20 component finishes are tabulated in Table 11. The N(10%) data are graphically presented in Figure 61. Using the N(10%) value for tin-lead soldered tin-lead CLCC-20 components as the baseline, the N(10%) values for the tin-lead soldered tin-silver-copper-bismuth and the tin-lead soldered tin-silver-copper CLCC-20 components are less than the baseline and therefore, do not meet the JTP acceptance criteria. The same result is achieved if N(63%) values are used for the comparison.

Table 11 Number of Cycles to 1, 10 and 63 Percent Failures for CLCC-20 on Rework Test Vehicles

Condition	Solder Paste	CLCC Finish	N(1%)	N(10%)	N(63%)
No Rework	SnPb	SnAgCu	161	209	268
No Rework	SnPb	SnAgCuBi	176	230	296
No Rework	SnPb	SnPb	198	280	388

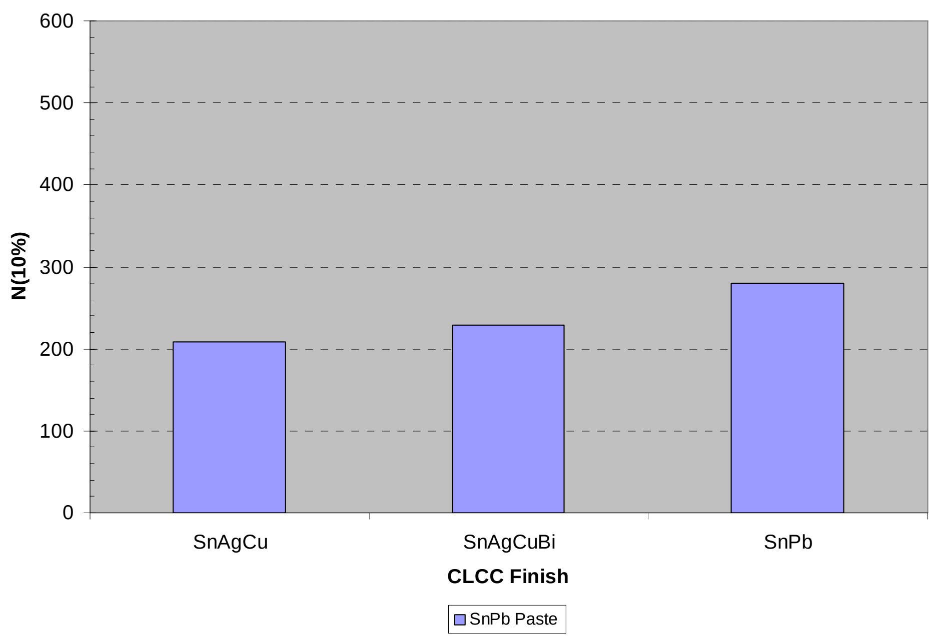

Figure 61 Chart of N(10%) for CLCC-20 on Rework Test Vehicles

PDIP-20 Results and Discussion

The only PDIP-20 components that failed were seven reworked tin-silver-copper soldered gold-palladium-nickel finish, two reworked tin-copper soldered gold-palladium-nickel finish and one tin-lead soldered gold-palladium-nickel finished PDIP-20 components. None of the unreworked PDIP-20 components failed. The Weibull plot reworked for tin-silver-copper soldered gold-palladium-nickel PDIP-20 components is shown in Figure 62. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the rework status, solder alloy then the component finish.

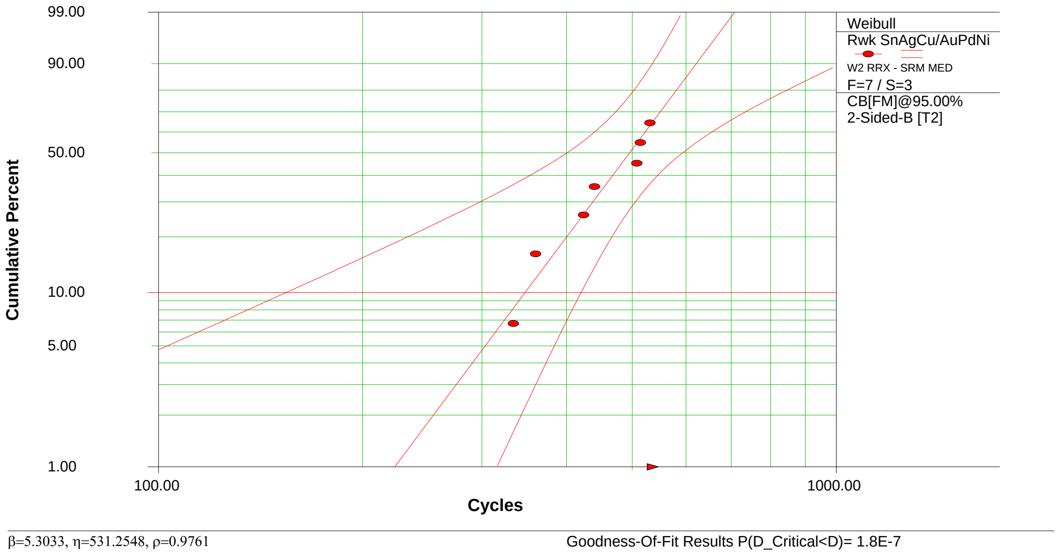

Figure 62 Weibull Plot of Reworked Gold-Palladium-Nickel PDIP-20 with Tin-Silver-Copper Solder Wire on Rework Test Vehicles

The Weibull plot for reworked tin-copper soldered gold-palladium-nickel PDIP-20 components is shown in Figure 63. Only two of the ten components failed. Therefore, there is not a sufficient sample size to constitute a sound statistical sample.

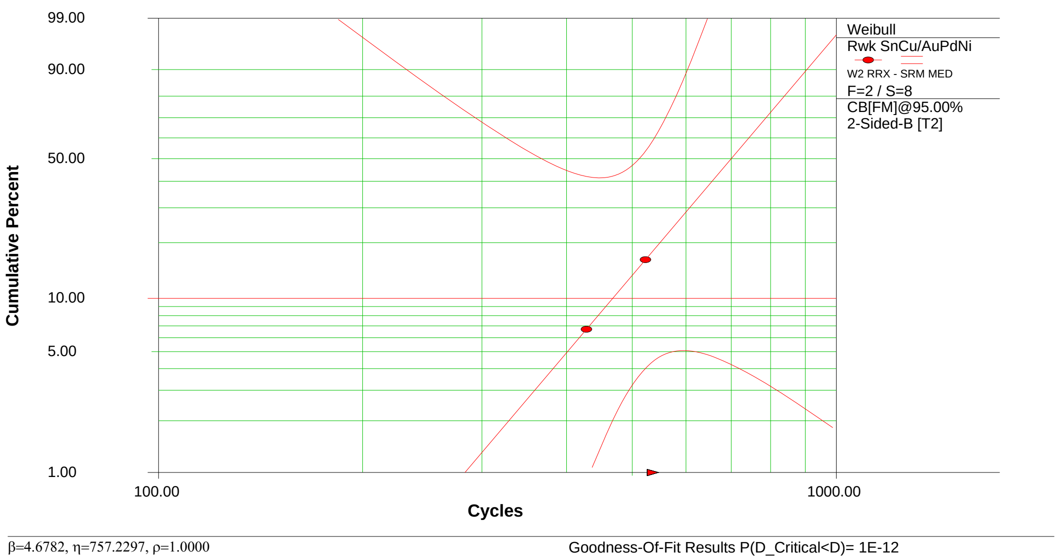

Figure 63 Weibull Plot of Reworked Gold-Palladium-Nickel PDIP-20 with Tin-Copper Solder Wire on Rework Test Vehicles

The Weibull plots were combined to facilitate comparative analysis. Figure 64 contains Weibull plots of reworked tin-silver-copper soldered gold-palladium-nickel and reworked tin-copper soldered gold-palladium-nickel PDIP-20 components. Since only one reworked tin-lead soldered tin-lead PDIP component failed, a Weibull plot could not be generated and used as a baseline. There is not a sufficient sample size in which to draw statistically sound comparisons in solder alloy performance.

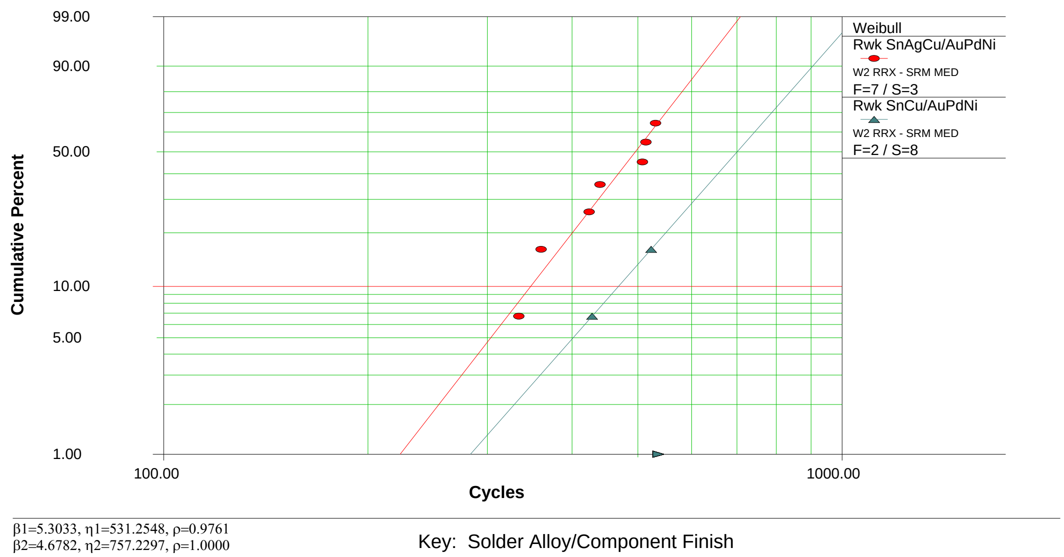

Figure 64 Weibull Plots of Reworked PDIP-20 on Rework Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for PDIP-20 components on rework test vehicles:

- The probability that reworked tin-lead soldered tin-lead PDIP-20 components will last longer than reworked tin-silver-copper soldered gold-palladium-nickel PDIP-20 components is 80%.
- The probability that reworked tin-lead soldered tin-lead PDIP-20 components will last longer than reworked tin-copper soldered gold-palladium-nickel PDIP-20 components is 73%.

Therefore, reworked tin-lead soldered tin-lead PDIP-20 components will last longer than reworked tin-silver-copper soldered gold-palladium-nickel and reworked tin-copper soldered gold-palladium-nickel PDIP-20 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the reworked PDIP-20 components are tabulated in Table 12 and graphically presented in Figure 65. There is not a sufficient sample size in which to draw statistically sound comparisons in solder alloy performance.

Table 12 Number of Cycles to 1, 10 and 63 Percent Failures for PDIP-20 on Rework Test Vehicles

Condition	Solder Wire	PDIP Finish	N(1%)	N(10%)	N(63%)
Reworked	SnAgCu	AuPdNi	223	348	531
Reworked	SnCu	AuPdNi	283	468	757

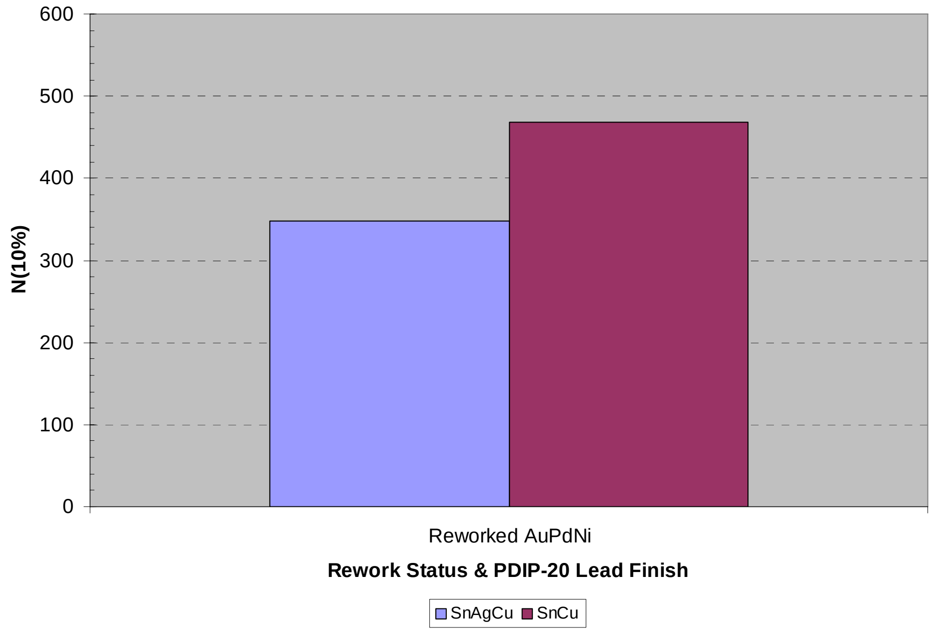

Figure 65 Chart of Number of Cycles to 10% Cumulative Failures for PDIP-20 on Rework Test Vehicles

TQFP-144 Results and Discussion

As part of the test plan, none of the TQFP-144 components were reworked. All of the TQFP-144 components were soldered with tin-lead solder paste. The Weibull plot for tin-lead soldered tin TQFP-144 components is shown in Figure 66. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a good fit of the data since the data reside within the 95-percent confidence limits and the goodness-of-fit results are nearly zero.

Figure 66 Weibull Plot of Tin TQFP-144 with Tin-Lead Solder Paste on Rework Test Vehicles

TQFP-208 Results and Discussion

The Weibull plot for unreworked tin-lead soldered gold-palladium-nickel TQFP-208 components is shown in Figure 67. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a good fit of the data as the data fit within the 95-percent confidence limits and the goodness-of-fit test results is near zero.

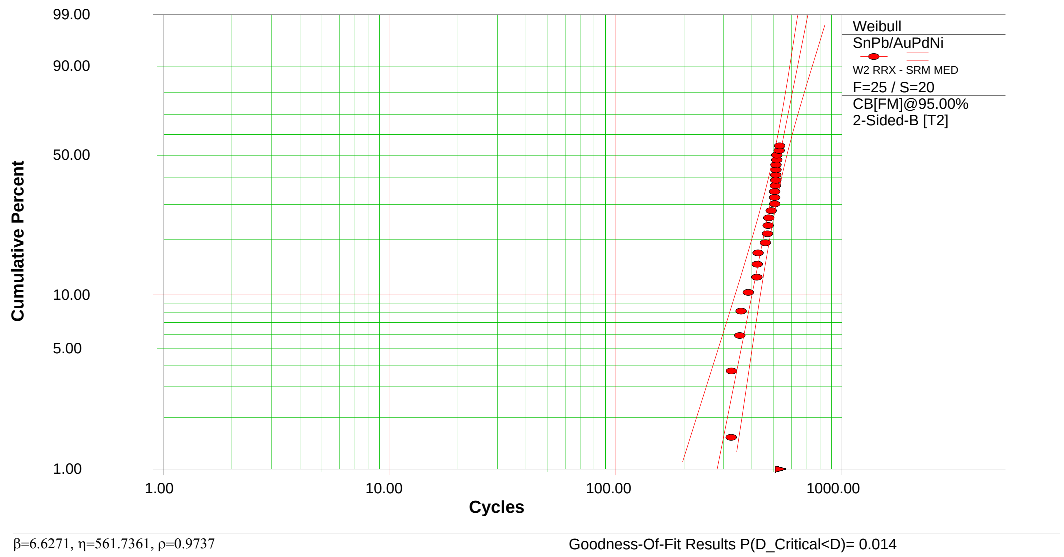

Figure 67 Weibull Plot of Gold-Palladium-Nickel TQFP-208 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components is shown in Figure 68. The 2-parameter Weibull regression is a good fit of the data as the data fit within the 95-percent confidence limits and the goodness-of-fit test results is near zero.

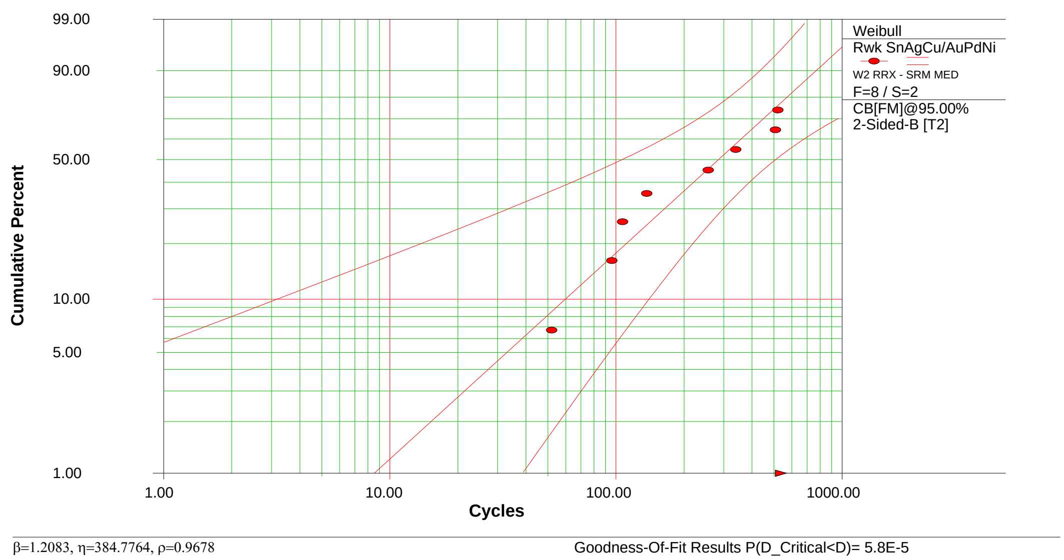

Figure 68 Weibull Plot of Reworked Gold-Palladium-Nickel TQFP-208 with Tin-Silver-Copper Solder Wire on Rework Test Vehicles

The Weibull plot for reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components is shown in Figure 69. The 2-parameter Weibull regression is a good fit of the data as the data is within the 95-percent confidence limits and the goodness-of-fit test result is low. There appears to be a bimodal distribution in the data requiring further analysis.

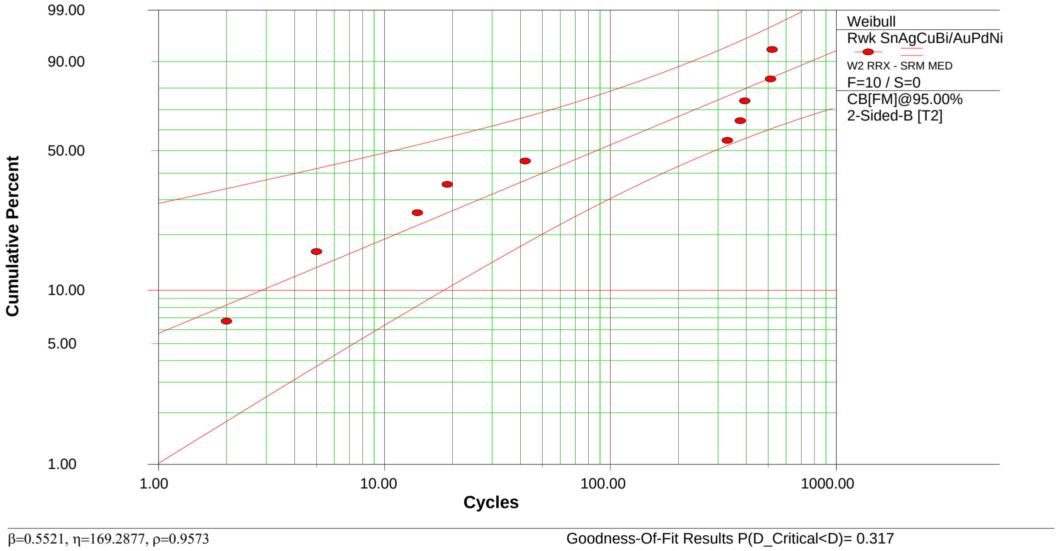

Figure 69 Weibull Plot of Reworked Gold-Palladium-Nickel TQFP-208 with Tin-Silver-Copper-Bismuth Solder Wire on Rework Test Vehicles

The Weibull plot for reworked tin-lead reworked gold-palladium-nickel TQFP-208 components is shown in Figure 70. The 2-parameter Weibull regression is a good fit of the data as the data fit within the 95-percent confidence limits and the goodness-of-fit test results is near zero.

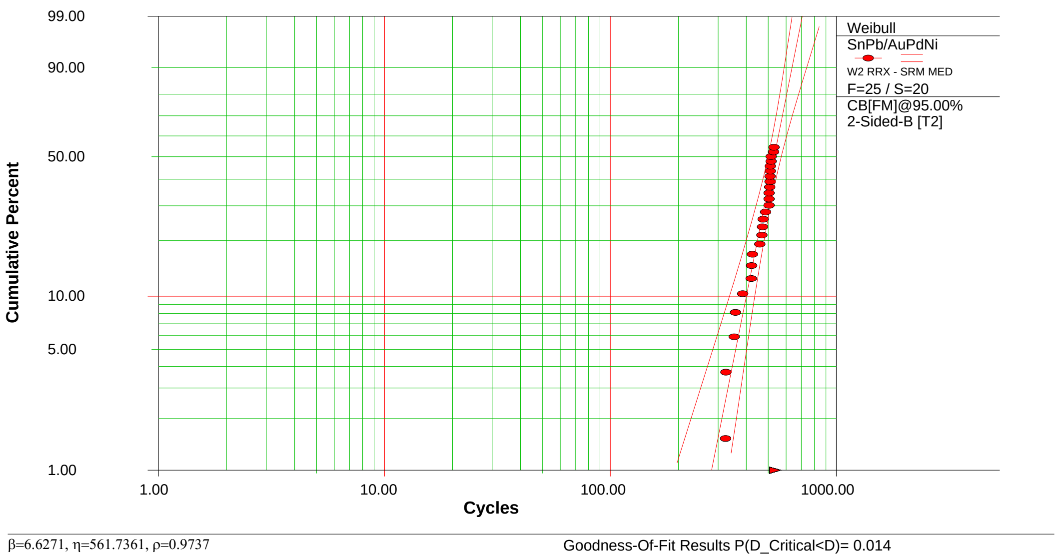

Figure 70 Weibull Plot of Reworked Gold-Palladium-Nickel TQFP-208 with Tin-Lead Solder Wire on Rework Test Vehicles

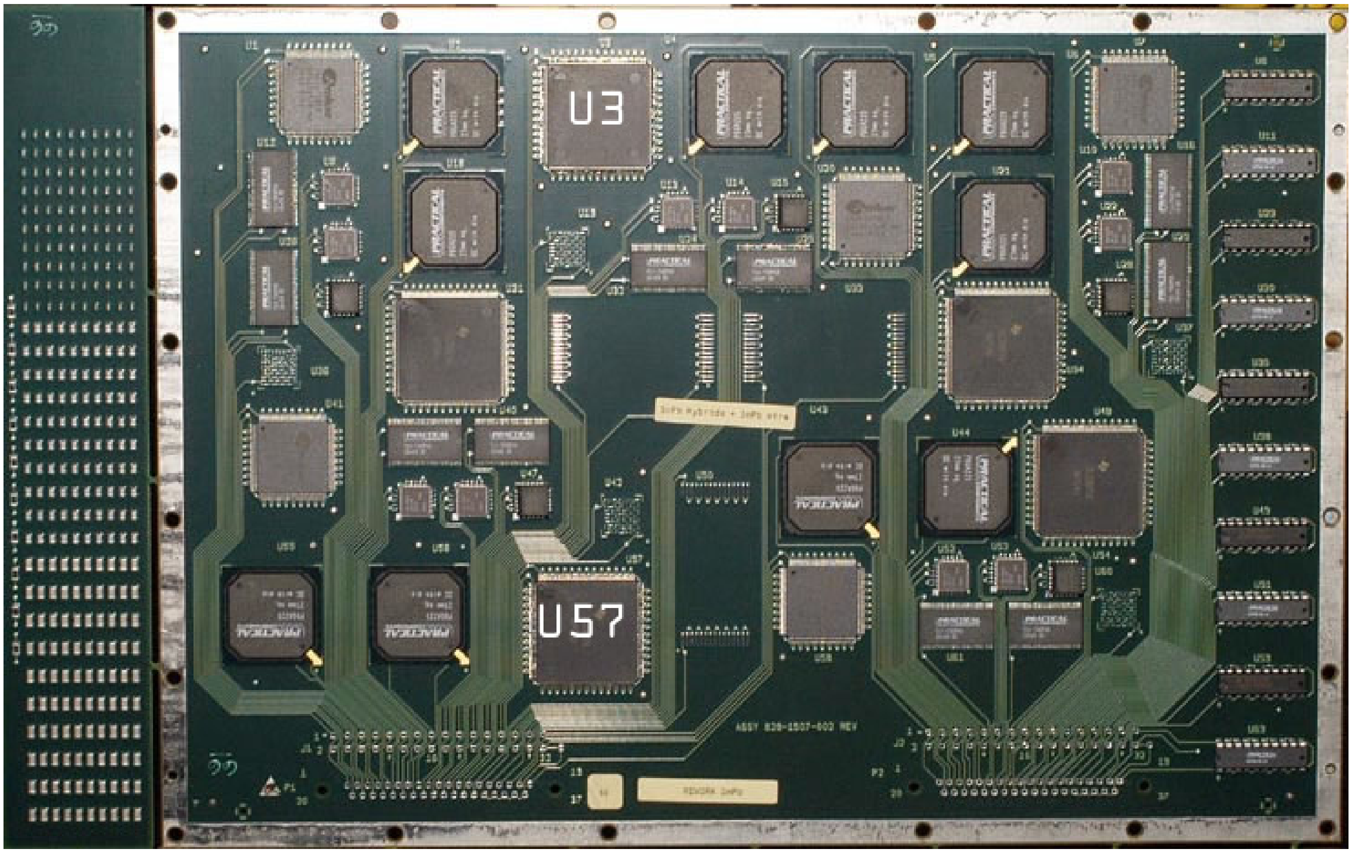

Figure 71 Photograph of Rework Test Vehicle Showing Reworked TQFP-208 Component Locations

The failure data for the reworked components were further subdivided by component location and analyzed (see Figure 71). Figure 72 shows the Weibull plots of U3 and U57 reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components. The plot shows the U3 components failed faster than the U57 components.

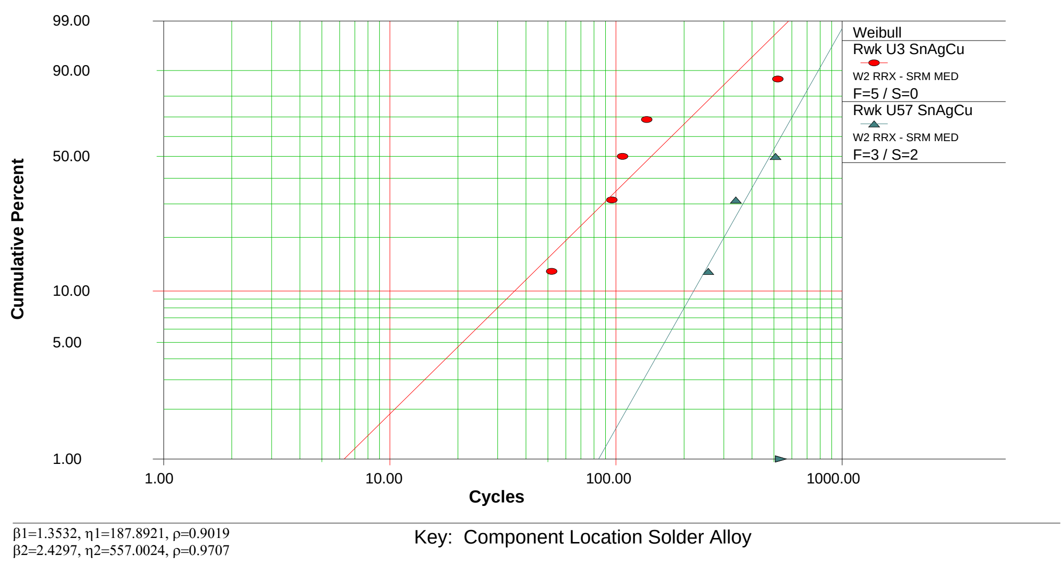

Figure 72 Weibull Plots of Reworked U3 vs. U57 TQFP-208 with Tin-Silver-Copper Solder Wire on Rework Test Vehicles

Figure 73 shows the Weibull plots of U3 and U57 reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components. The plot shows the U3 components failed much faster than the U57 components.

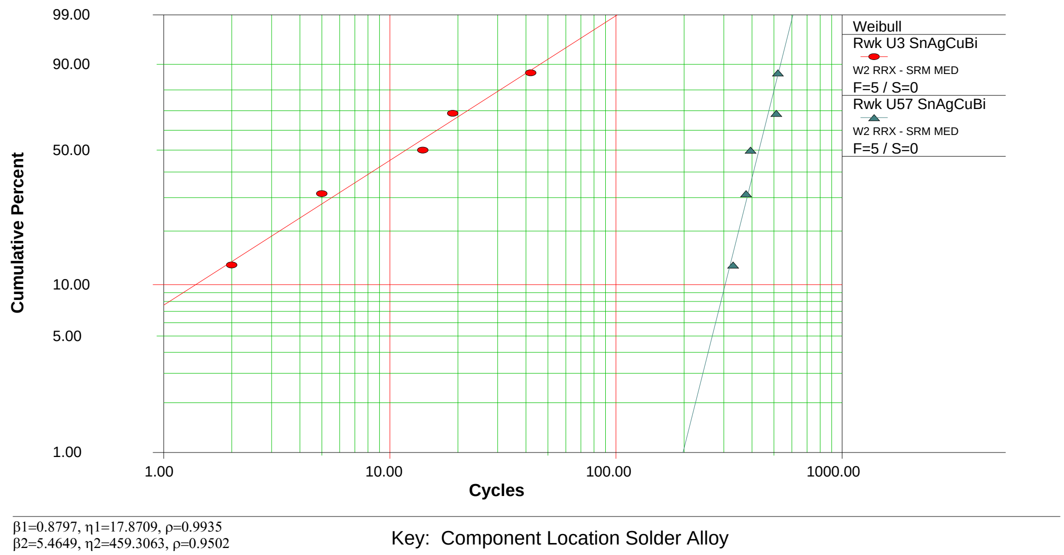

Figure 73 Weibull Plots of Reworked U3 vs. U57 TQFP-208 with Tin-Silver-Copper-Bismuth Solder Wire on Rework Test Vehicles

Figure 74 shows the Weibull plots of U3 and U57 reworked tin-lead soldered gold-palladium-nickel TQFP-208 components. The plot shows the U3 components failed slightly faster than the U57 components.

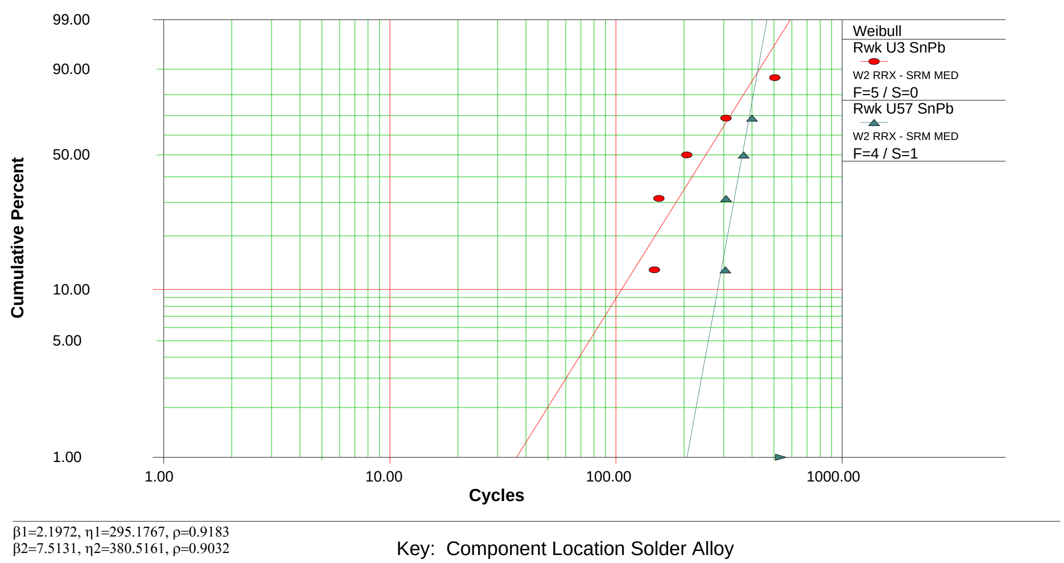

Figure 74 Weibull Plots of Reworked U3 vs. U57 TQFP-208 with Tin-Lead Solder Wire on Rework Test Vehicles

Figure 75 shows the Weibull plots of U57 components reworked. The plot shows similar performance for the three solder alloys.

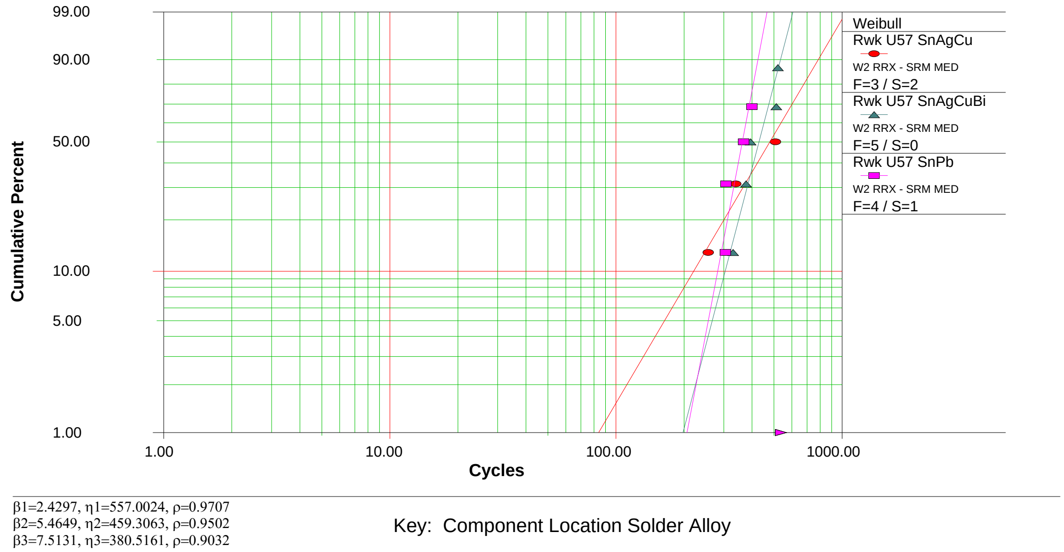

Figure 75 Weibull Plots of Reworked U57 TQFP-208 on Rework Test Vehicles

Figure 76 shows the Weibull plots of U3 reworked components by rework solder alloy. The plot shows a large variation in solder alloy performance for U3 components. U3 components reworked with tin-silver-copper-bismuth failed much sooner than U3 components reworked with tin-silver-copper solder. U3 components reworked with tin-lead solder performed the best. This indicates the U3 location had a negative influence in solder joint reliability, had a greater impact on the lead-free solder alloys in general, and greatly degraded the performance of tin-silver-copper-bismuth solder. Component location on the board with respect to vibration stress levels, organic contamination or intermetallic formation on the U3 printed circuit board pads may be the cause of the solder joint reliability degradation. Destructive failure analysis is recommended to determine the actual cause.

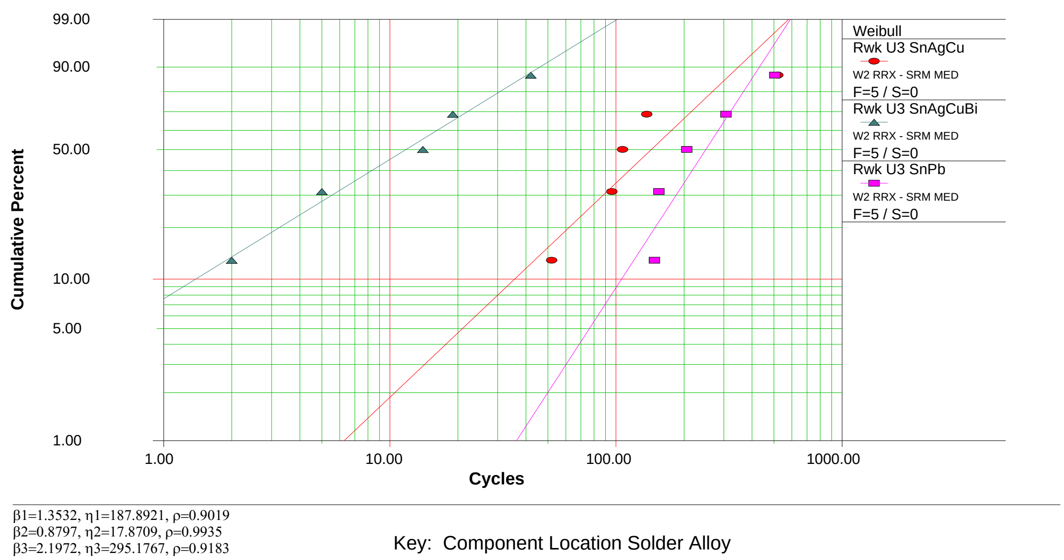

Figure 76 Weibull Plots of Reworked U3 TQFP-208 on Rework Test Vehicles

The Weibull plots were combined to facilitate comparative analysis. Figure 77 contains Weibull plots of reworked tin-silver-copper soldered gold-palladium-nickel and reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components compared to reworked tin-lead soldered gold-palladium-nickel TQFP-

208 components. The plots show reworked tin-lead soldered gold-palladium-nickel TQFP-208 components performed best with reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components second and reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components last. The reliability of the reworked tin-silver-copper-bismuth soldered TQFP-208 components was negatively impacted by the poor reliability of the reworked components at location U3.

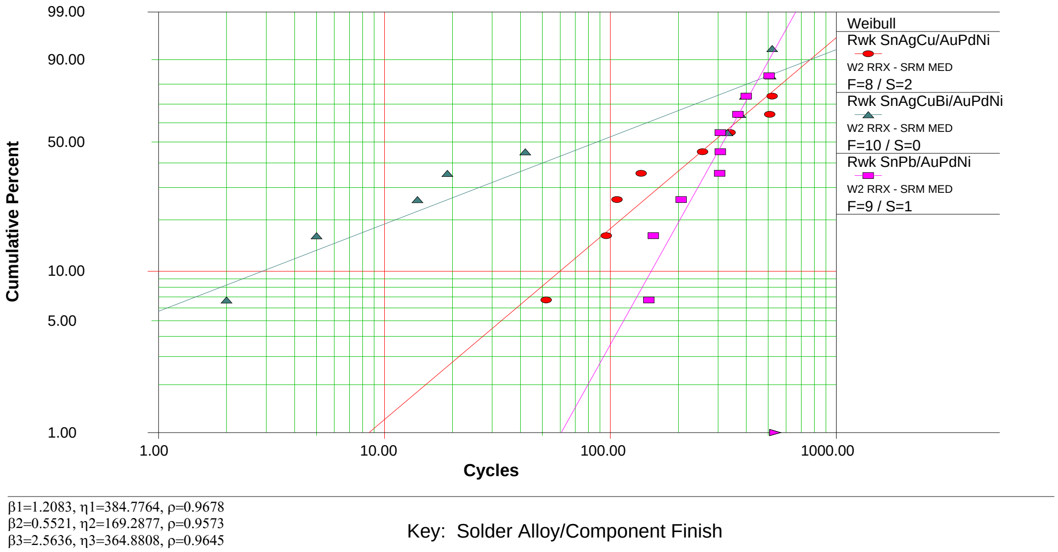

Figure 77 Weibull Plot of Reworked Gold-Palladium-Nickel TQFP-208 on Rework Test Vehicles

Figure 78 contains Weibull plots of all TQFP-208 components on rework test vehicles. The plots show unreworked tin-lead soldered gold-palladium-nickel TQFP-208 components performed best with reworked tin-lead soldered gold-palladium-nickel TQFP-208 components second, reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components third and reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components last.

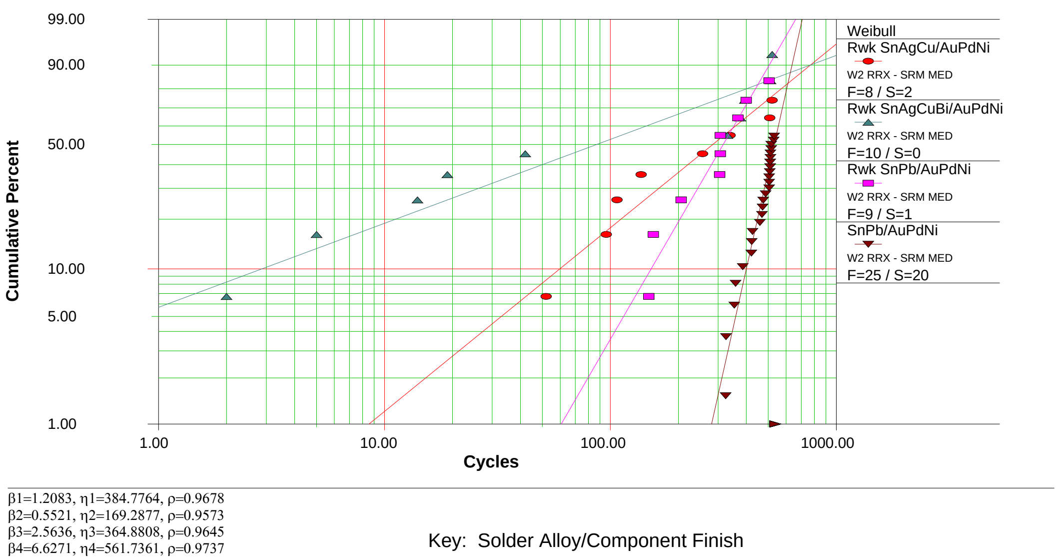

Figure 78 Weibull Plots of Gold-Palladium-Nickel TQFP-208 on Rework Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for TQFP-208 components on rework test vehicles:

- The probability that reworked tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components is 53%. Based on the above probability both data sets are probably from the same population.
- The probability that reworked tin-lead soldered gold-palladium-nickel TSFP-208 components will last longer than reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components is 74%.
- The probability that reworked tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than unreworked tin-lead soldered gold-palladium-nickel TQFP-208 components is 12%.

Therefore, unreworked tin-lead soldered gold-palladium-nickel TQFP-208 components will last longer than reworked tin-lead soldered gold-palladium-nickel TQFP-208 components, which will last longer than reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components, which will last longer than reworked tin-silver-copper-bismuth soldered gold-palladium-nickel TQFP-208 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the TQFP-208 components are tabulated in Table 13. The N(10%) data are graphically presented in Figure 79. Using the N(10%) value for the reworked tin-lead soldered gold-palladium-nickel TQFP-208 components as the baseline, the N(10%) values for the reworked tin-silver-copper-bismuth soldered gold-palladium-nickel and reworked tin-silver-copper soldered gold-palladium-nickel TQFP-208 components are less than the baseline and therefore, do not meet the JTP acceptance criteria. Using the N(63%) values as the basis for comparison alters the results slightly. The reworked tin-silver-copper soldered TQFP-208 components meet the acceptance criteria when N(63%) is the basis for the comparison.

Table 13 Number of Cycles to 1, 10 and 63 Percent Failures for TQFP-208 on Rework Test Vehicles

Condition	Solder Wire	Lead Finish	N(1%)	N(10%)	N(63%)
Reworked	SnAgCu	AuPdNi	9	60	385
Reworked	SnAgCuBi	AuPdNi	0	3	169
Reworked	SnPb	AuPdNi	61	152	365
No Rework	SnPb	AuPdNi	281	400	562

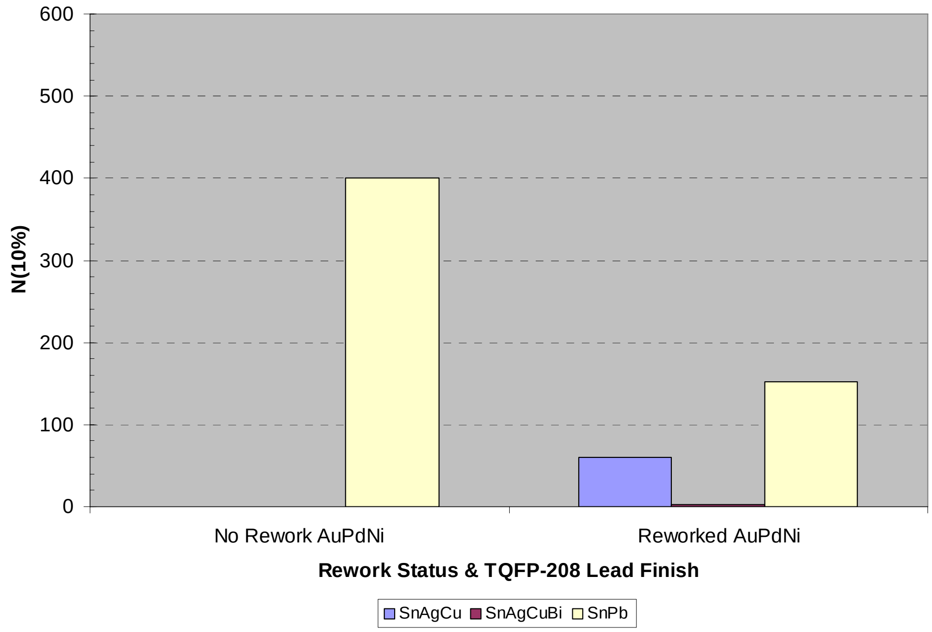

Figure 79 Chart of Number of Cycles to 10% Cumulative Failures for TQFP-208 on Rework Test Vehicles

TSOP-50 Results and Discussion

The Weibull plot for unreworked tin-lead soldered tin-copper TSOP-50 components is shown in Figure 80. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a poor fit of the data since many data points exceed the 95-percent confidence limits and the goodness-of-fit result is near one. There appears to be a "stairstep" in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data correspond to the step increases in the vibration levels that occurred as part of the test plan.

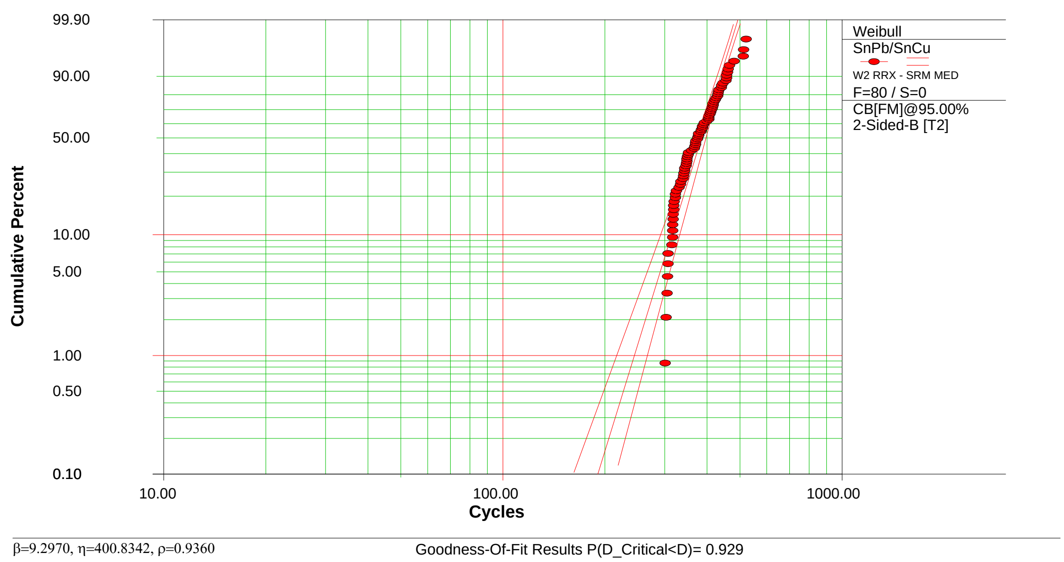

Figure 80 Weibull Plot of Tin-Copper TSOP-50 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for unreworked tin-lead soldered tin-lead TSOP-50 components is shown in Figure 81. The 2-parameter Weibull regression is a good fit of the data since a few of the data exceed the 95-percent confidence limits and the goodness-of-fit result is low. There appears to be a slight "stairstep" in the data with vertical jumps near the time where the vibration level increases occurred.

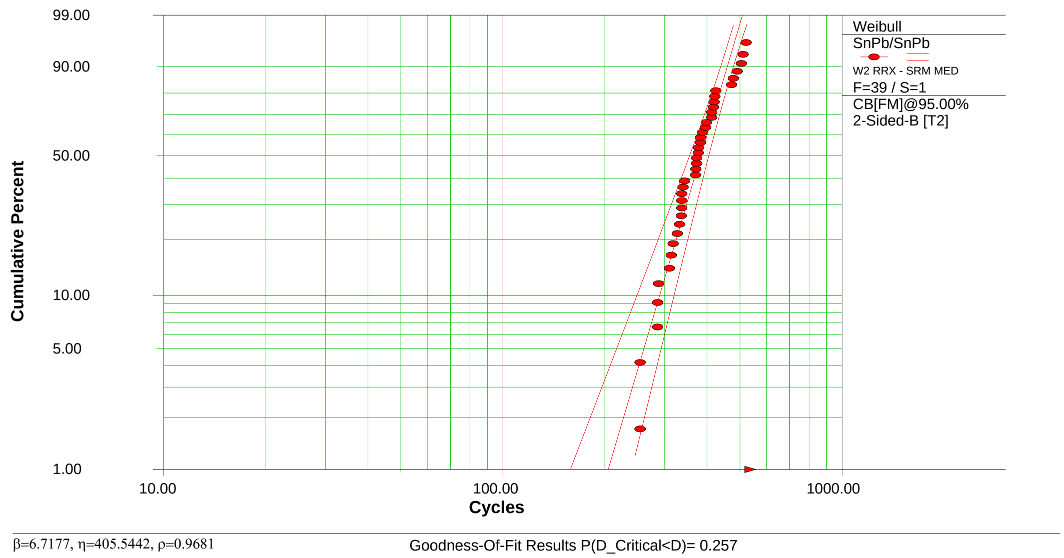

Figure 81 Weibull Plot of Tin-Lead TSOP-50 with Tin-Lead Solder Paste on Rework Test Vehicles

The Weibull plot for reworked tin-silver-copper soldered tin-copper TSOP-50 components is shown in Figure 82. The 2-parameter Weibull regression is a good fit of the data since the data are within the 95-percent confidence limits and the goodness-of-fit result is low. There appears to be a slight "stairstep" in the data with vertical jumps near the time where the vibration level increases occurred.

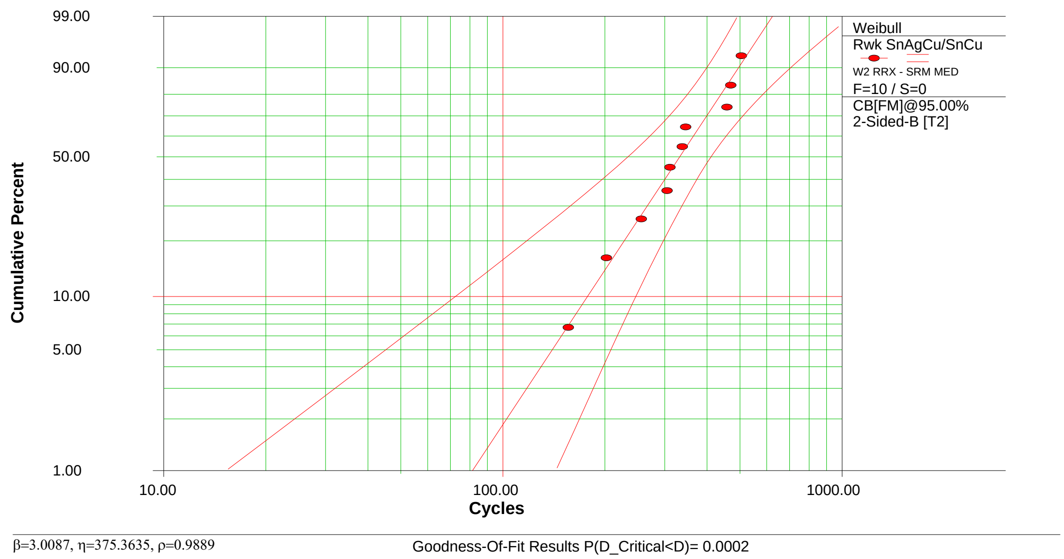

Figure 82 Weibull Plot of Reworked Tin-Copper TSOP-50 with Tin-Silver-Copper Solder Wire on Rework Test Vehicles

The Weibull plot for reworked tin-silver-copper-bismuth soldered tin-lead TSOP-50 components is shown in Figure 83. The 2-parameter Weibull regression is a fair fit of the data since all of the data points are inside the 95-confidence limits and the goodness-of-fit result is low. There appears to be two slopes within the data that may indicate multiple failure modes occurred.

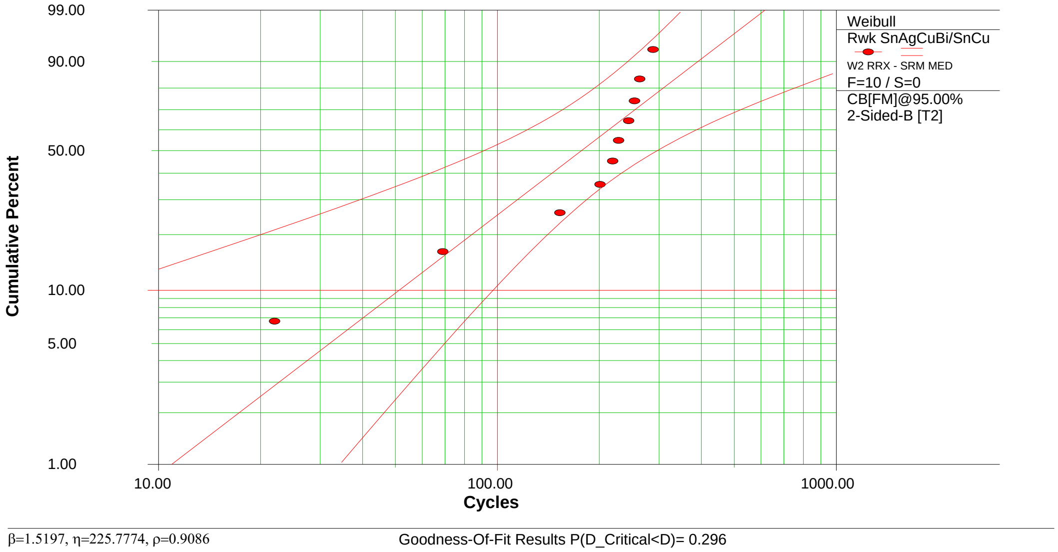

Figure 83 Weibull Plot of Reworked Tin-Copper TSOP-50 with Tin-Silver-Copper-Bismuth Solder Wire on Rework Test Vehicles

The Weibull plot for reworked tin-lead soldered tin-lead TSOP-50 is shown in Figure 84. The 2-parameter Weibull regression is a good fit of the data since the data fall within the 95-percent confidence limits and the goodness-of-fit results is low.

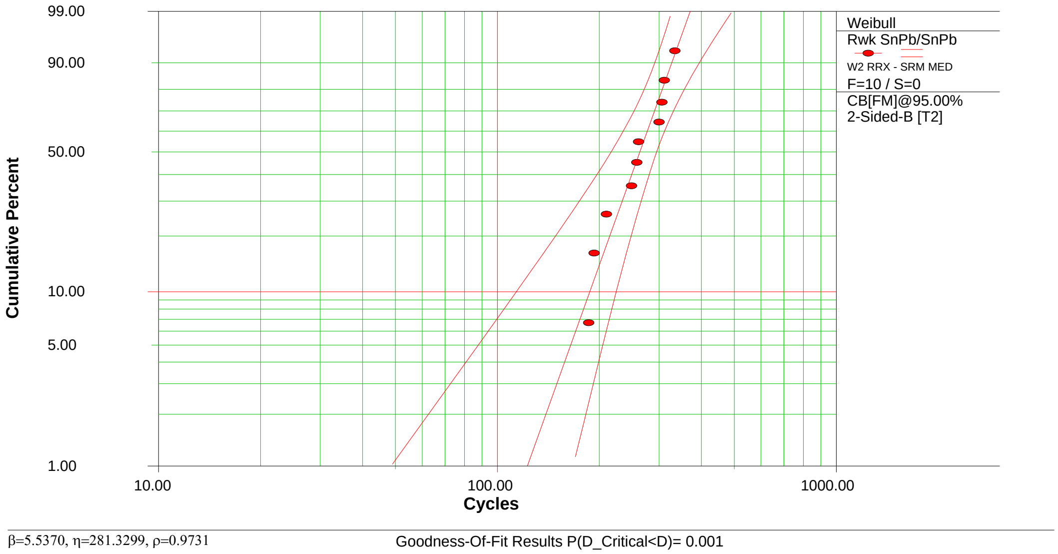

Figure 84 Weibull Plot of Reworked Tin-Lead TSOP-50 with Tin-Lead Solder Wire on Rework Test Vehicles

Several of the Weibull plots in different rework status, lead finish and solder alloys combinations were combined to facilitate comparative analysis. Figure 85 contains Weibull plots of the reworked TSOP-50 components reworked with the lead-free solder alloys compared to reworked tin-lead soldered tin-lead TSOP-50 components. The plot shows reworked tin-silver-copper soldered tin-copper TSOP-50 components performed similarly to the reworked tin-lead soldered tin-lead TSOP-50 components. Reworked tin-silver-copper-bismuth soldered tin-copper TSOP-50 components performed poorly. The poor performance of the tin-silver-copper-bismuth soldered TSOP-50 may be a result of the very small amounts of lead contamination left on the board pads from the rework action.

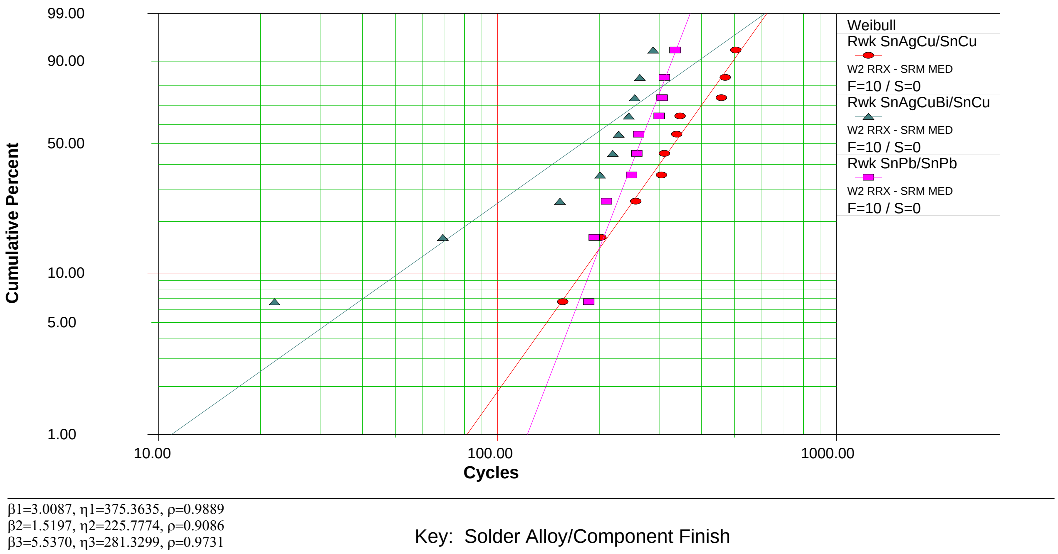

Figure 85 Weibull Plots of Reworked TSOP-50 on Rework Test Vehicles

Figure 86 combines Weibull plots of unreworked tin-copper and tin-lead TSOP-50 components soldered with tin-lead solder paste. The plot shows the lead finish did not affect the solder joint reliability of the TSOP-50 components.

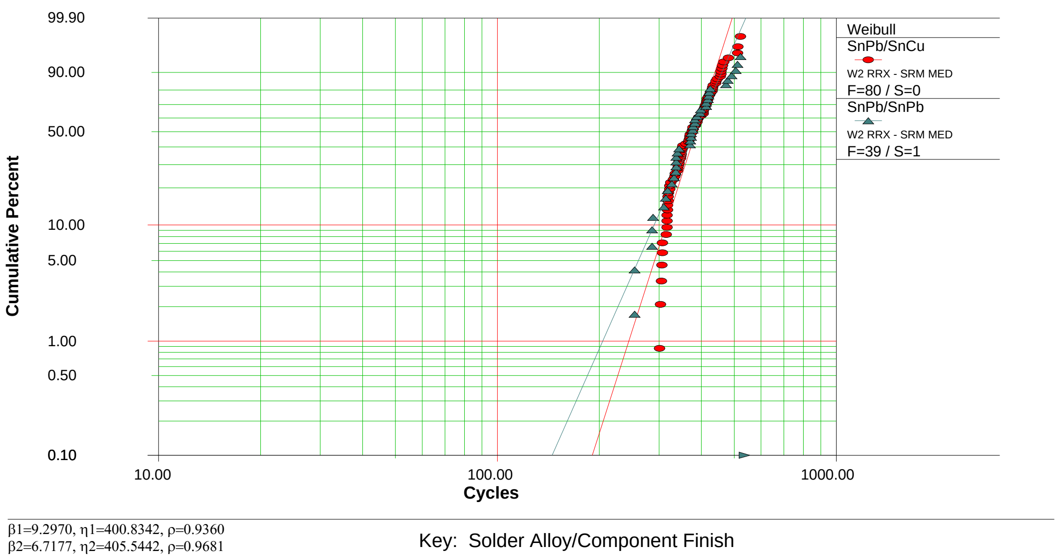

Figure 86 Weibull Plots of Tin-Copper vs. Tin-Lead TSOP-50 with Tin-Lead Solder Paste on Rework Test Vehicles

Figure 87 contains the Weibull plots for all of the combinations of rework status, component finish and solder alloy for the TSOP-50 components on the rework test vehicles. Overall, the unreworked tin-lead soldered tin-copper and unreworked tin-lead soldered tin-lead TSOP-50 components performed better than the reworked TSOP-50 components. Reworked tin-silver-copper soldered tin-copper TSOP-50 components performed as well as reworked tin-lead soldered tin-lead TSOP-50 components. Reworked tin-silver-copper-bismuth soldered tin-copper TSOP-50 components performed the worst. Residual tin-lead solder left on the component pads dramatically degraded the reliability of reworked TSOP-50 when soldered with the tin-silver-copper-bismuth solder.

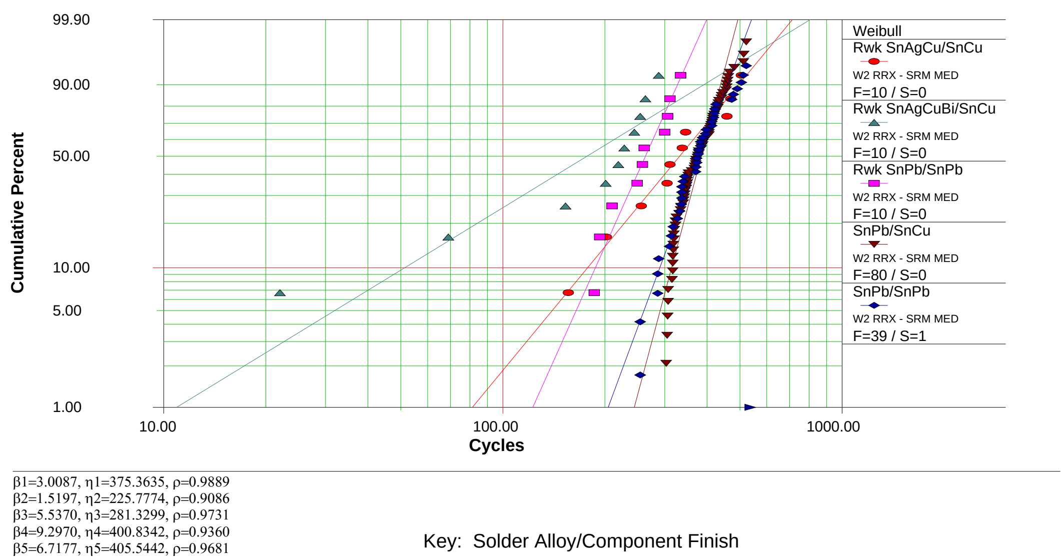

Figure 87 Weibull Plots of TSOP-50 on Rework Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for TSOP-50 components on rework test vehicles:

- The probability that reworked tin-lead soldered tin-lead TSOP-50 components will last longer than reworked tin-silver-copper soldered tin-copper TSOP-50 components is 30%.
- The probability that reworked tin-lead soldered tin-lead TSOP-50 components will last longer than reworked tin-silver-copper-bismuth soldered tin-copper TSOP-50 components is 69%.
- The probability that reworked tin-lead soldered tin-lead TSOP-50 components will last longer than unreworked tin-lead soldered tin-copper TSOP-50 components is 5%.
- The probability that reworked tin-lead soldered tin-lead TSOP-50 components will last longer than unreworked tin-lead soldered tin-lead TSOP-50 components is 9%.
- The probability that unreworked tin-lead soldered tin-lead TSOP-50 components will last longer than unreworked tin-lead soldered tin-copper TSOP-50 components is 50%. Both data sets are from the same population.

Therefore, reworked tin-silver-copper soldered tin-copper TSOP-50 components will last longer than reworked tin-lead soldered tin-lead TSOP-50 components. The reworked tin-lead soldered tin-lead TSOP-50 components will last longer than the reworked tin-silver-copper-bismuth soldered tin-copper TSOP-50 components. Unreworked tin-lead soldered tin-copper and tin-lead soldered tin-lead TSOP-50 components will last longer than reworked tin-lead soldered tin-lead TSOP-50 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various TSOP-50 rework condition, component finishes and solder alloys are tabulated in Table 14. The N(10%) data are graphically presented in Figure 88. Using the N(10%) value for the reworked tin-lead soldered tin-lead TSOP-50 components as the baseline, the N(10%) values for the reworked tin-silver-copper-bismuth soldered tin-copper and reworked tin-silver-copper soldered tin-copper TSOP-50 components are less than the baseline and therefore, do not meet the JTP acceptance criteria. Using the N(10%) value for unreworked tin-lead soldered tin-lead TSOP-50 components as the baseline, the N(10%) value for the unreworked tin-lead soldered tin-copper TSOP-50 components is greater than the baseline and therefore, meets the JTP acceptance criteria. If N(63%) is used as the basis for comparison, only reworked tin-silver-copper-bismuth soldered tin-copper TSOP-50 meet the acceptance criteria.

Table 14 Number of Cycles to 1, 10 and 63 Percent Failures for TSOP-50 on Rework Test Vehicles

Condition	Solder Wire	Lead Finish	N(1%)	N(10%)	N(63%)
Reworked	SnAgCu	SnCu	81	178	375
Reworked	SnAgCuBi	SnCu	11	51	226
Reworked	SnPb	SnPb	123	187	281
No Rework	SnPb	SnCu	244	315	401
No Rework	SnPb	SnPb	204	290	406

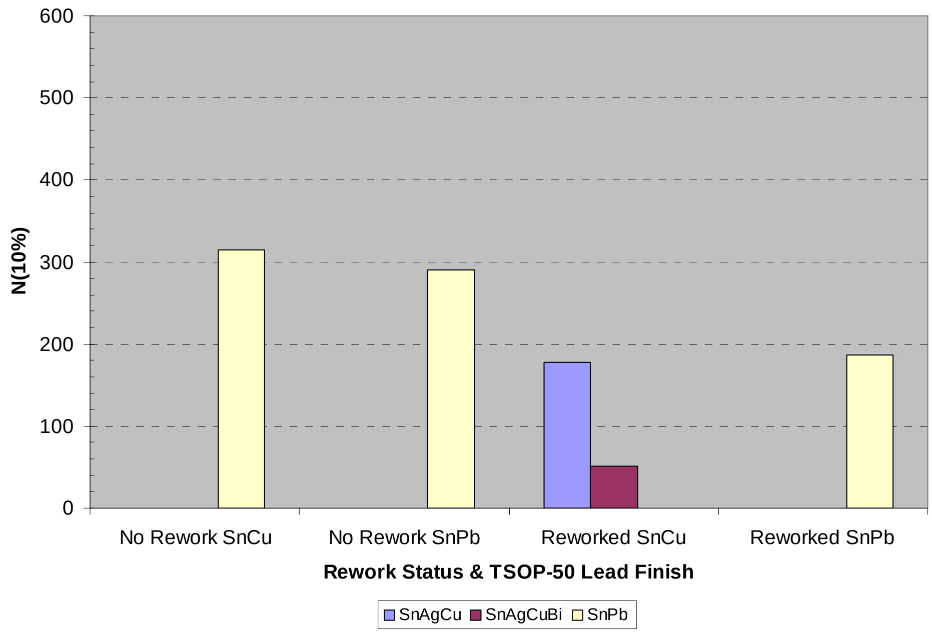

Figure 88 Chart of Number of Cycles to 10% Cumulative Failures for TSOP-50 on Rework Test Vehicles

Hybrid Test Vehicle Results and Discussion

The hybrid test vehicles were tested for 500 cycles. The raw data are tabulated in Table 21 on page 79. Failures at ten cycles or lower were excluded by team consensus. The team felt these early life failures were due to manufacturing or testing anomalies and the data should be excluded to prevent skewing the test results. One tin-silver-copper-bismuth soldered tin-silver-copper CSP-100 component failed during the second cycle and the datum was excluded from the Weibull analysis. The test vehicles were inspected for lead damage or broken wires. No wires or component leads were noted as broken on the hybrid test vehicles.

The data were compiled by assembly serial number, component type and component finish, and tabulated in Table 15. The data show test vehicles 323, 335 and 337 show a lower number of failed components compared to the other test vehicles. This suggests these test vehicles may have experienced lower thermal and/or vibration stresses during the testing.

Table 15 Number of Failed Components by Hybrid Test Vehicle

Component & Finish	Test Vehicle Serial Number															Total
	301	302	303	305	306	323	324	325	326	327	332	333	335	336	337	
CSP SnAgCu						5	5	5	5	5	5	5	5	5	5	**50**
CSP SnPb	5	5	5	5	5											**25**
Hybrid SnAgCu						1	3	3	2	3						**12**
Hybrid SnAgCuBi											2	2	0	3	1	**8**
Hybrid SnPb	3	3	3	3	3											**15**
TOTAL	**8**	**8**	**8**	**8**	**8**	**6**	**8**	**8**	**7**	**8**	**7**	**7**	**5**	**8**	**6**	**110**

The data were also segregated by component type, component finish and solder alloy and tabulated in Table 16. Test vehicles soldered with tin-silver-copper-bismuth solder had fewer solder joints fail with 82 percent of the components registering as a failure. The test vehicles soldered with tin-silver-copper had the next best performance with 92 percent of the components registering as a failure. Test vehicles soldered with tin-lead solder were worst with 100 percent of the components registering as a failure. Not enough plated-through-hole components failed to be able to rate the performance of the wave solder alloys.

Table 16 Number of Failed Components by Component, Component Finish and Solder Alloy on Hybrid Test Vehicles

Component & Finish	Solder Alloy		
	SnAgCu Paste	SnAgCuBi Paste	SnPb Paste
CSP SnAgCu	100% (25 of 25)	100% (25 of 25)	
CSP SnPb			100% (25 of 25)
Hybrid SnAgCu	80% (12 of 15)		
Hybrid SnAgCuBi		53% (8 of 15)	
Hybrid SnPb			100% (15 of 15)
Grand Total	**92% (37 of 40)**	**82% (33 of 40)**	**100% (40 of 40)**

CSP-100 Results and Discussion

The Weibull plot for tin-silver-copper soldered tin-silver-copper CSP-100 is shown in Figure 89. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right of the chart indicates the solder alloy then component finish. The 2-parameter Weibull plot is a good fit of the data given the data fall within the confidence limits and the goodness-of-fit result is low. There appears to be a “stairstep” in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures. Many of the vertical jumps in the data occur where step increases in the vibration levels occurred as part of the test plan.

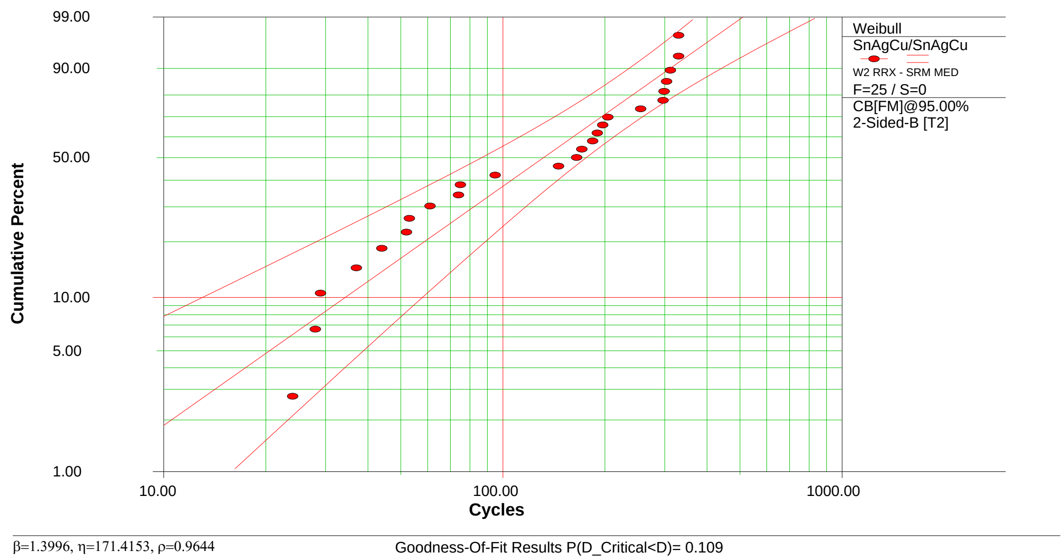

Figure 89 Weibull Plot of SnAgCu CSP-100 with SnAgCu Paste on Hybrid Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-silver-copper CSP-100 is shown is Figure 90. The 2-parameter Weibull plot is a good fit of the data since all of the data fit inside the 95-percent confidence limits and the goodness-of-fit result is relatively low. There appears to be a "stairstep" in the data.

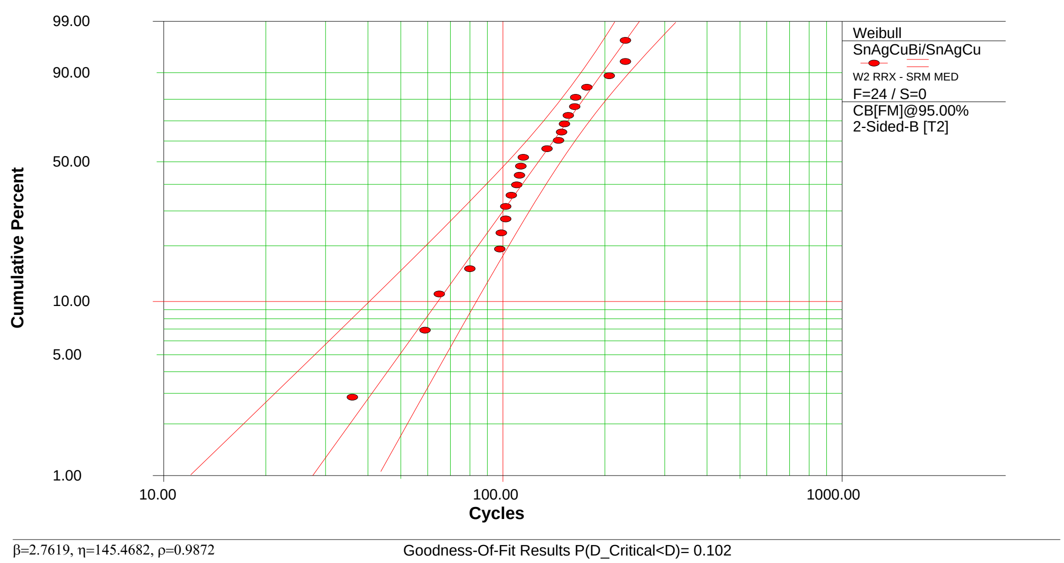

Figure 90 Weibull Plot of SnAgCu CSP-100 with SnAgCuBi Paste on Hybrid Test Vehicles

The Weibull plot for tin-lead soldered tin-lead CSP-100 is shown is Figure 91. The 2-parameter Weibull plot is a poor fit of the data since some of the data are outside the 95-percent confidence limits and the goodness-of-fit result is near one.

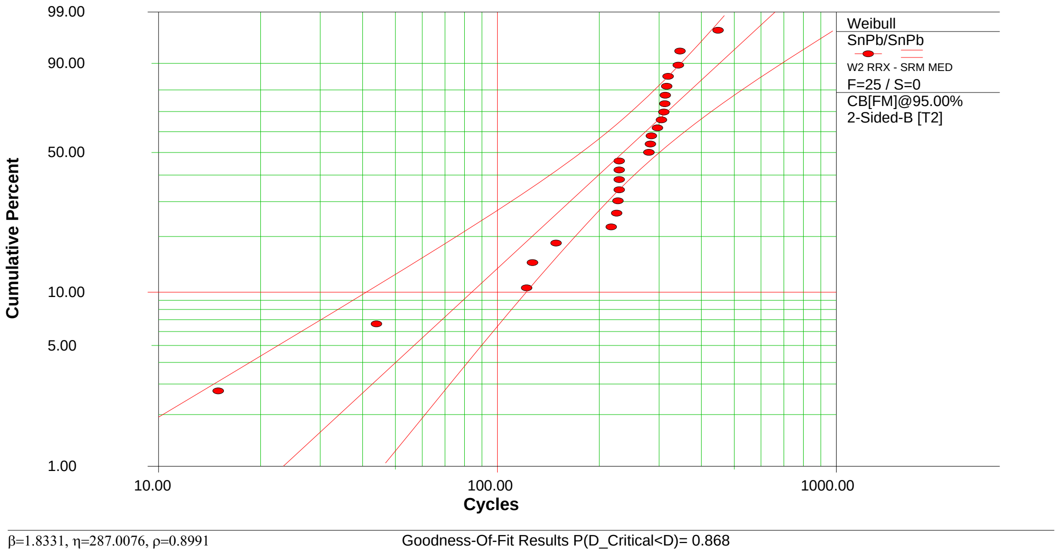

Figure 91 Weibull Plot of SnPb CSP-100 with SnPb Paste on Hybrid Test Vehicles

The Weibull plots were combined to facilitate comparative analysis. Figure 92 contains Weibull plots of tin-silver-copper CSP-100 components soldered with lead-free solders compared to tin-lead soldered tin-lead CSP-100 components. The plot shows fitted line for the tin-silver-copper-bismuth solder crosses the other fitted lines making comparative analysis difficult and dependent on which part of the plots are used for the analysis. Based on ten percent cumulative failures, tin-lead solder performed best with tin-silver-copper-bismuth solder second and tin-silver-copper solder last.

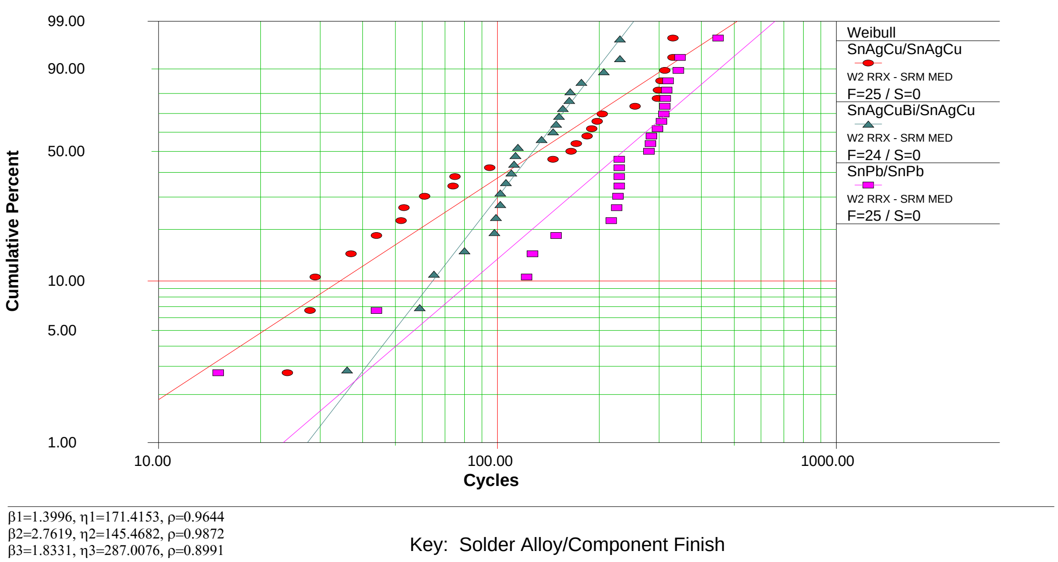

Figure 92 Weibull Plots of CSP-100 on Hybrid Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for CSP-100 components on hybrid test vehicles:

- The probability that tin-lead soldered tin-lead CSP-100 components will last longer than tin-silver-copper soldered tin-silver-copper CSP-100 components is 71%.

- The probability that tin-lead soldered tin-lead CSP-100 components will last longer than tin-silver-copper-bismuth soldered tin-silver-copper CSP-100 components is 78%.
- The probability that tin-silver-copper soldered tin-silver-copper CSP-100 components will last longer than tin-silver-copper-bismuth soldered tin-silver-copper CSP-100 components is 53%. Based on the above probability both data sets are probably from the same population.

Therefore, the tests of comparison results show tin-lead soldered tin-lead CSP-100 components will last longer than the CSP-100 components soldered with the lead-free solders.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the CSP-100 component finishes and solder alloys are tabulated in Table 17. The N(10%) data are graphically presented in Figure 93. Using the N(10%) value for tin-lead soldered tin-lead CSP-100 components as the baseline, the N(10%) values for the tin-silver-copper and tin-silver-copper-bismuth soldered tin-silver-copper CSP-100 components are less than baseline and therefore, do not meet the JTP acceptance criteria. The same result is achieved when the N(63%) values are used as the basis for the comparison.

Table 17 Number of Cycles to 1, 10 and 63 Percent Failures for CSP-100 on Hybrid Test Vehicles

Solder Paste	CSP Ball	N(1%)	N(10%)	N(63%)
SnAgCu	SnAgCu	6	34	171
SnAgCuBi	SnAgCu	28	64	145
SnPb	SnPb	23	84	287

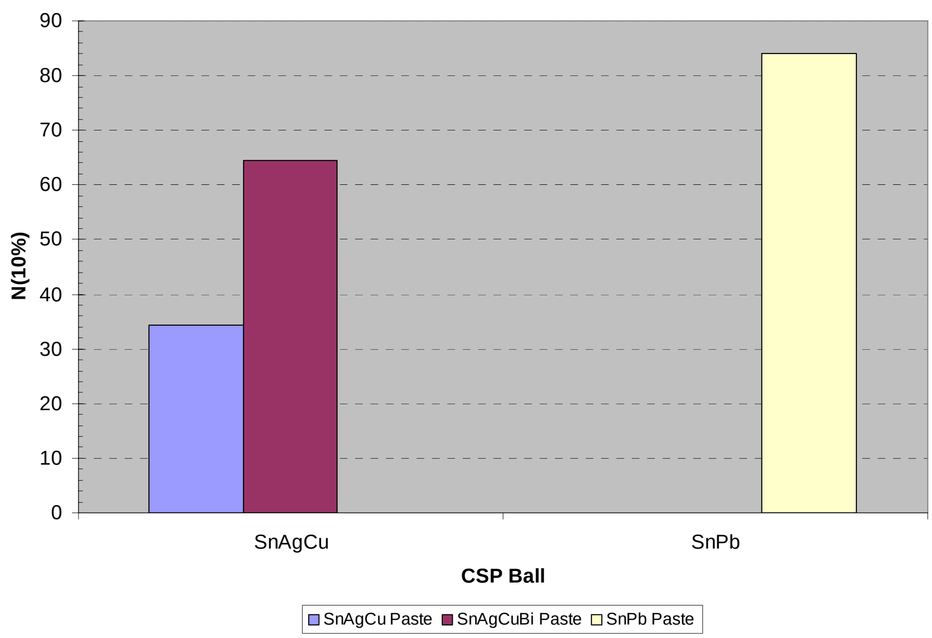

Figure 93 Chart of Number of Cycles to 10% Cumulative Failures for CSP-100 on Hybrid Test Vehicles

Hybrid Results and Discussion

The Weibull plot for tin-silver-copper soldered tin-silver-copper hybrid-30 components is shown in Figure 94. The plot includes the fitted line and the 95-percent confidence limits. The legend on the right side of the chart identifies the solder alloy then the component finish. The 2-parameter Weibull regression is a fair fit of the data since a datum falls on the 95-percent confidence limit and the goodness-of-fit result is low. There appears to be a large “stairstep” in the data indicating possible changes in stresses applied to the test vehicle or multiple failure modes in the solder joint failures.

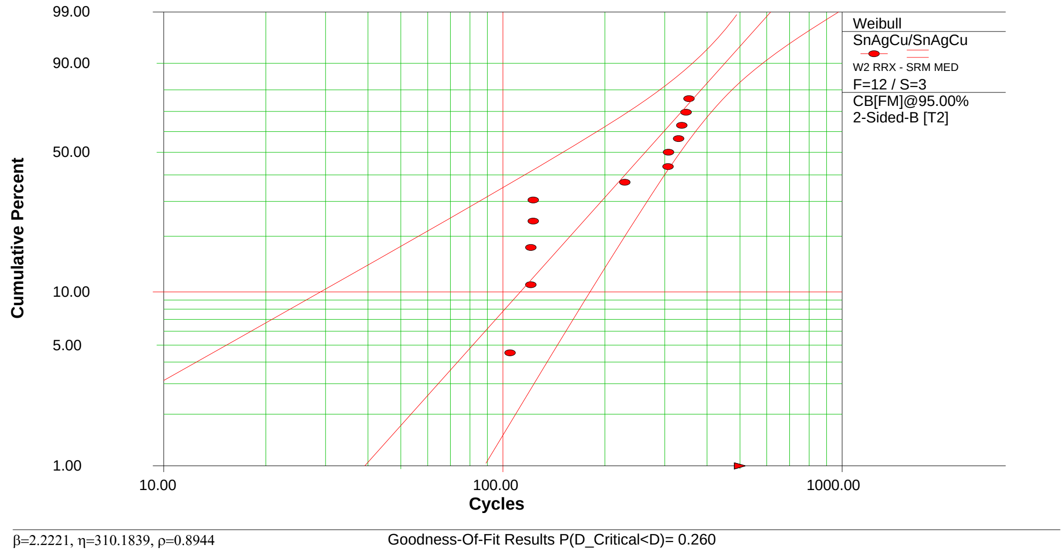

Figure 94 Weibull Plot of SnAgCu Hybrid-3o with SnAgCu Paste on Hybrid Test Vehicles

The Weibull plot for tin-silver-copper-bismuth soldered tin-silver-copper-bismuth hybrid-30 components is shown in Figure 95. The 2-parameter Weibull regression is an excellent fit of the data since all data are within the 95-percent confidence limits and the goodness-of-fit result is low.

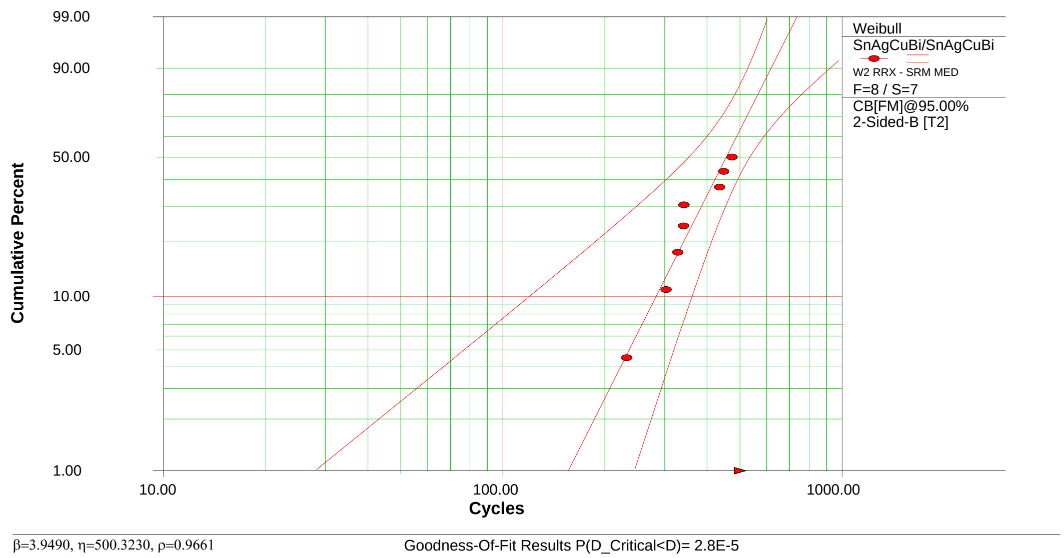

Figure 95 Weibull Plot of SnAgCuBi Hybrid-30 with SnAgCuBi Paste on Hybrid Test Vehicles

The Weibull plot for tin-lead soldered tin-lead hybrid-30 components is shown in Figure 96. The 2-parameter Weibull regression is a good fit of the data since most of the data reside within the 95-percent confidence limits and the goodness-of-fit result is low.

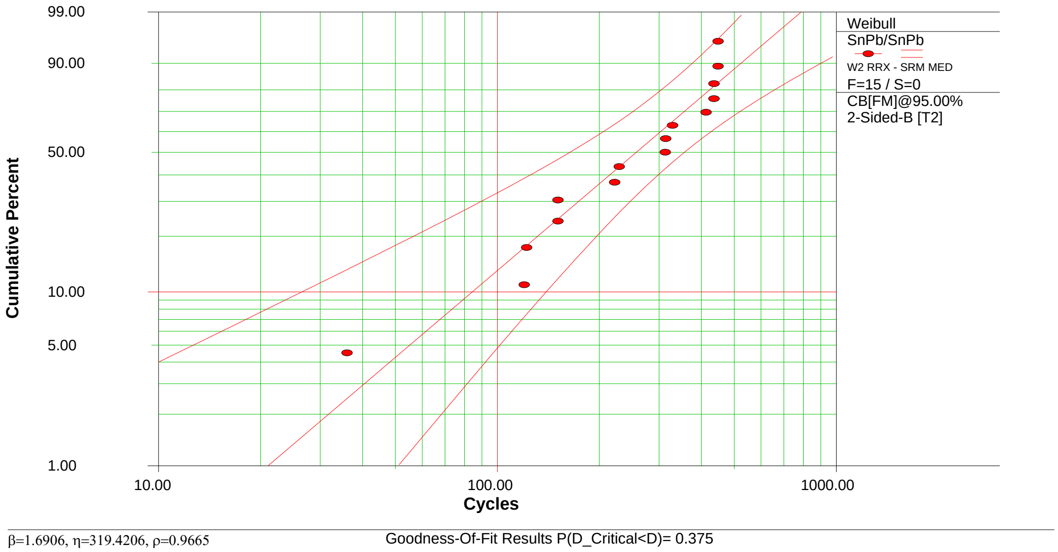

Figure 96 Weibull Plot of SnPb Hybrid-30 with SnPb Paste on Hybrid Test Vehicle

The Weibull plots were combined to facilitate comparative analysis. Figure 97 contains Weibull plots of tin-silver-copper soldered tin-silver-copper and tin-silver-copper-bismuth soldered tin-silver-copper-bismuth hybrid-30 components compared to tin-lead soldered tin-lead hybrid-30 components. The plot shows tin-silver-copper-bismuth solder performed best , tin-silver-copper solder second best and tin-lead solder the worst.

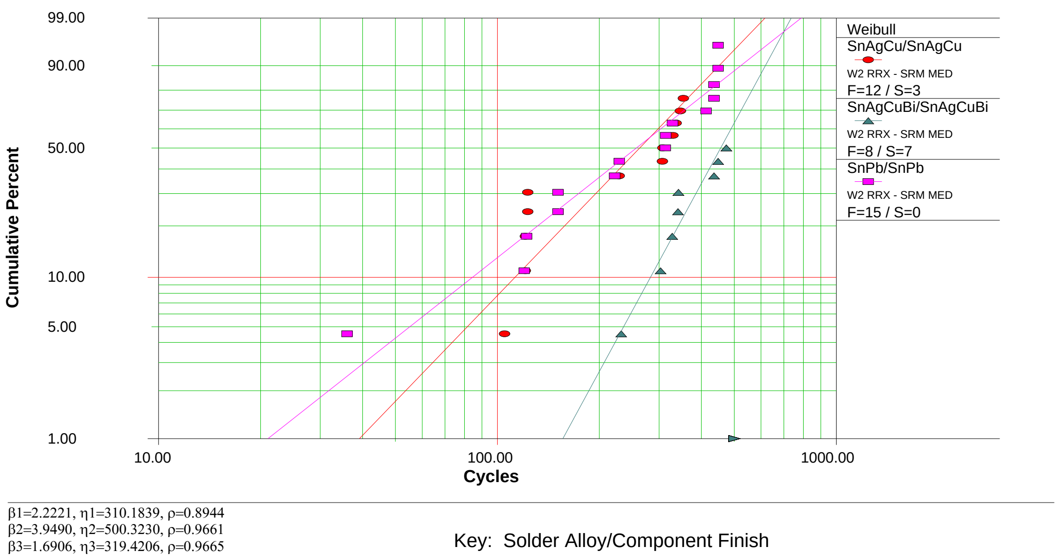

Figure 97 Weibull Plots of Hybrid-30 on Hybrid Test Vehicles

Based on the results of the Weibull++6 Tests of Comparison tool for hybrid-30 components on hybrid test vehicles:

- The probability that tin-lead soldered tin-lead hybrid-30 components will last longer than tin-silver-copper soldered tin-silver-copper hybrid-30 components is 50%. Both data sets are from the same population.

- The probability that tin-lead soldered tin-lead hybrid-30 components will last longer than tin-silver-copper-bismuth soldered tin-silver-copper-bismuth hybrid-30 components is 21%.

Therefore, tin-silver-copper-bismuth soldered tin-silver-copper-bismuth hybrid-30 components will last longer than tin-lead soldered tin-lead hybrid-30 components. The tin-lead soldered tin-lead hybrid-30 components are similar in reliability compared to the tin-silver-copper soldered tin-silver-copper hybrid-30 components.

The number of cycles to one, ten and 63 percent cumulative failures, N(1%), N(10%) and N(63%) respectively, for the various hybrid-30 component finishes and solder alloys are tabulated in Table 18. The N(10%) data are graphically presented in Figure 98. Using the N(10%) value for the tin-lead soldered tin-lead hybrid-30 components as the baseline, the N(10%) values for tin-silver-copper-bismuth and tin-silver-copper soldered hybrid-30 components are greater than the baseline and therefore, meet the JTP acceptance criteria. When the N(63%) values are used for comparison, only the tin-silver-copper-bismuth soldered hybrid-30 meets the acceptance criteria.

Table 18 Number of Cycles to 1, 10 and 63 Percent Failures for Hybrid-30 on Hybrid Test Vehicles

Solder Paste	Lead Finish	N(1%)	N(10%)	N(63%)
SnAgCu	SnAgCu	39	113	310
SnAgCuBi	SnAgCuBi	156	283	500
SnPb	SnPb	21	84	319

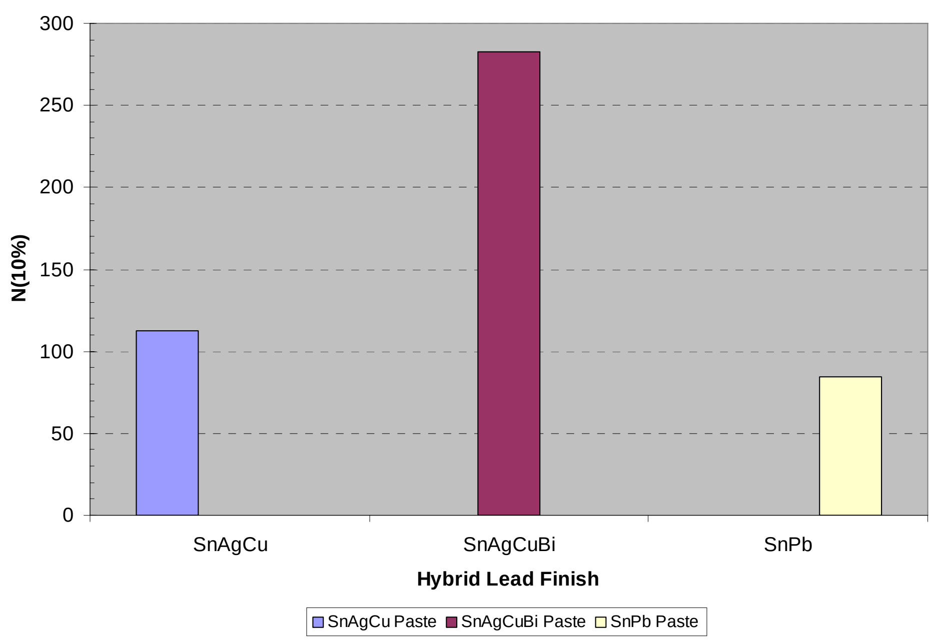

Figure 98 Chart of Number of Cycles to 10% Cumulative Failures for Hybrid-30 on Hybrid Test Vehicles

Comparison of Manufacture and Rework Test Vehicle Results

The Weibull plots for tin-lead solder components on manufacture test vehicles were plotted with the Weibull plots of the unreworked tin-lead soldered components on rework test vehicles. The comparison was made to determine the effects of the differences in laminate materials and board surface finishes. The manufacture test vehicle boards were fabricated from high glass transition temperature laminate with immersion silver surface finish. The rework test vehicles were fabricated from relatively low glass transition temperature laminate with hot air soldered level surface finish.

The comparison of tin-lead soldered tin-lead BGA-225 components on manufacture and rework test vehicles is shown in Figure 99. BGA-225 components on manufacture test vehicles were more robust than BGA-225 components on rework test vehicles.

The comparison of tin-lead soldered tin-lead CLCC-20 components on manufacture and rework test vehicles is shown in Figure 100. CLCC-20 components on manufacture test vehicles were similar in performance to the CLCC-20 components on rework test vehicles.

The comparison of tin-lead soldered tin TQFP-144 components on manufacture and rework test vehicles is shown in Figure 101. TQFP-144 components on manufacture test vehicles were more robust than TQFP-144 components on rework test vehicles.

The comparison of tin-lead soldered gold-palladium-nickel TQFP-208 components on manufacture and rework test vehicles is shown in Figure 102. TQFP-208 components on manufacture test vehicles were more robust than TQFP-208 components on rework test vehicles.

The comparison of tin-lead soldered tin-lead TSOP-50 components on manufacture and rework test vehicles is shown in Figure 103. TSOP-50 components on manufacture test vehicles were more robust than TSOP-50 components on rework test vehicles.

In general, the higher glass transition temperature laminate and immersion silver board surface finish appear to enhance the reliability of the solder joints.

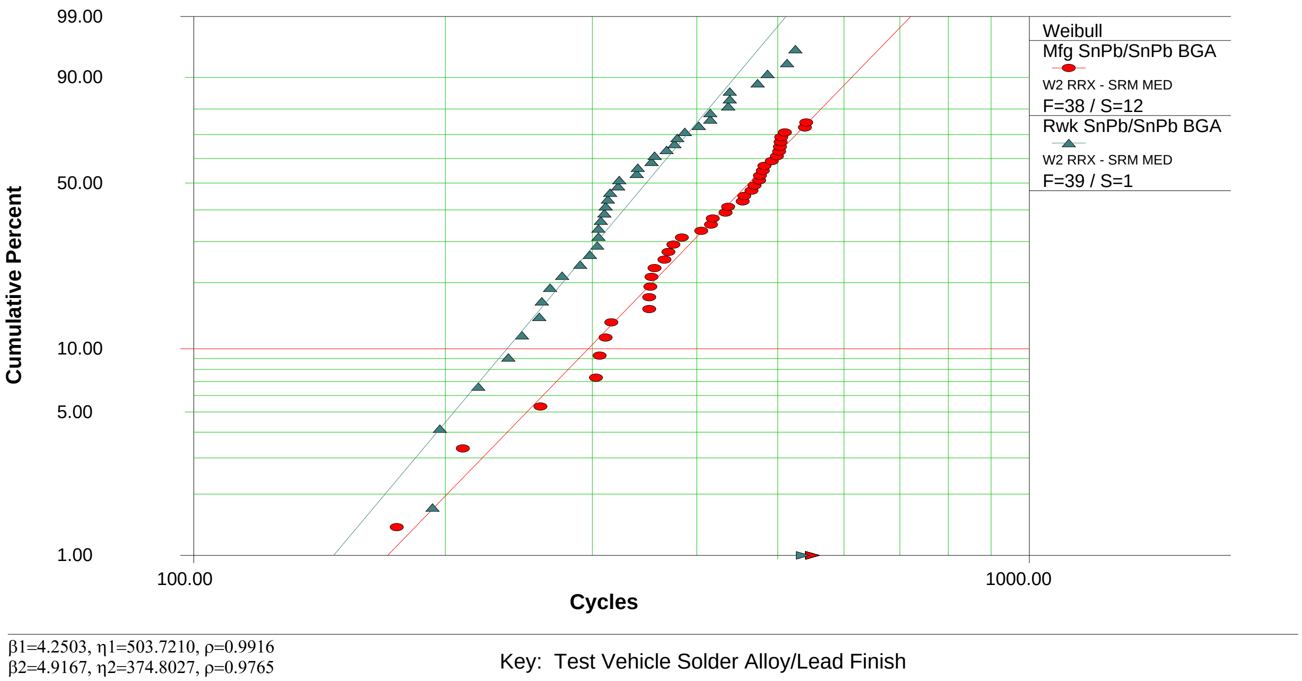

Figure 99 Comparison of Tin-Lead Soldered Tin-Lead BGA-225 on Manufacture and Rework Test Vehicles

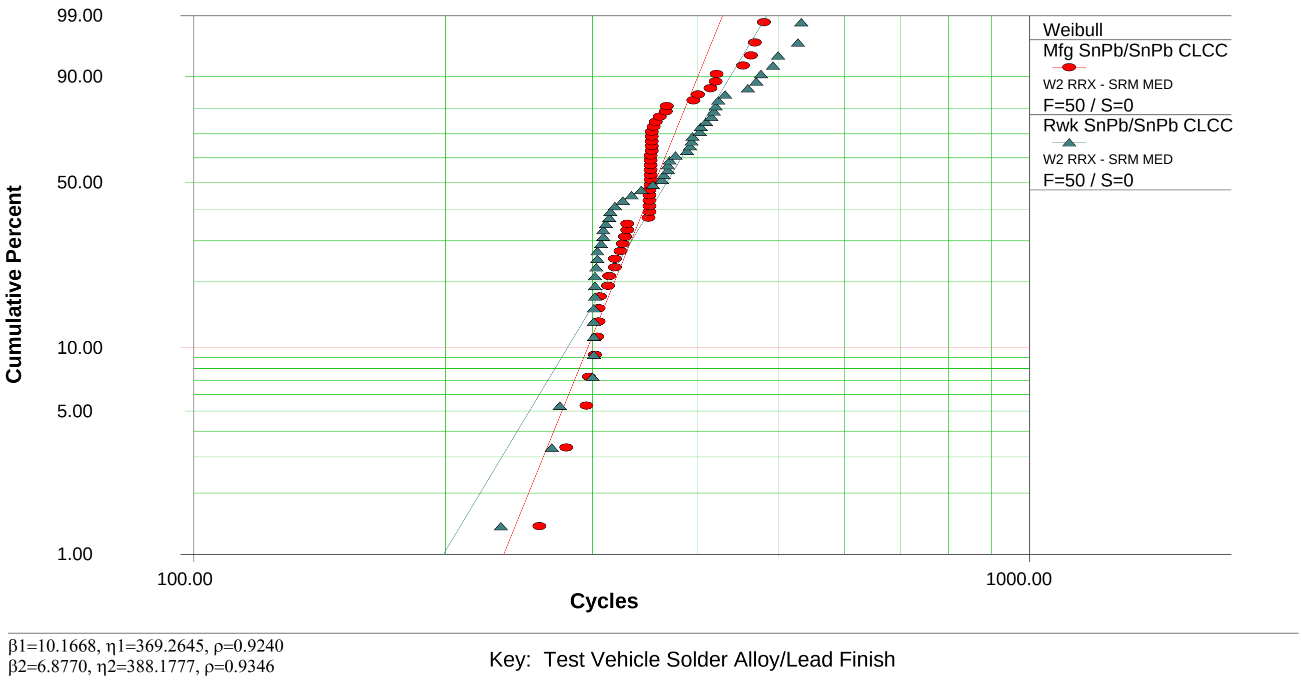

Figure 100 Comparison of Tin-Lead Soldered Tin-Lead CLCC-20 Components on Manufacture and Rework Test Vehicles

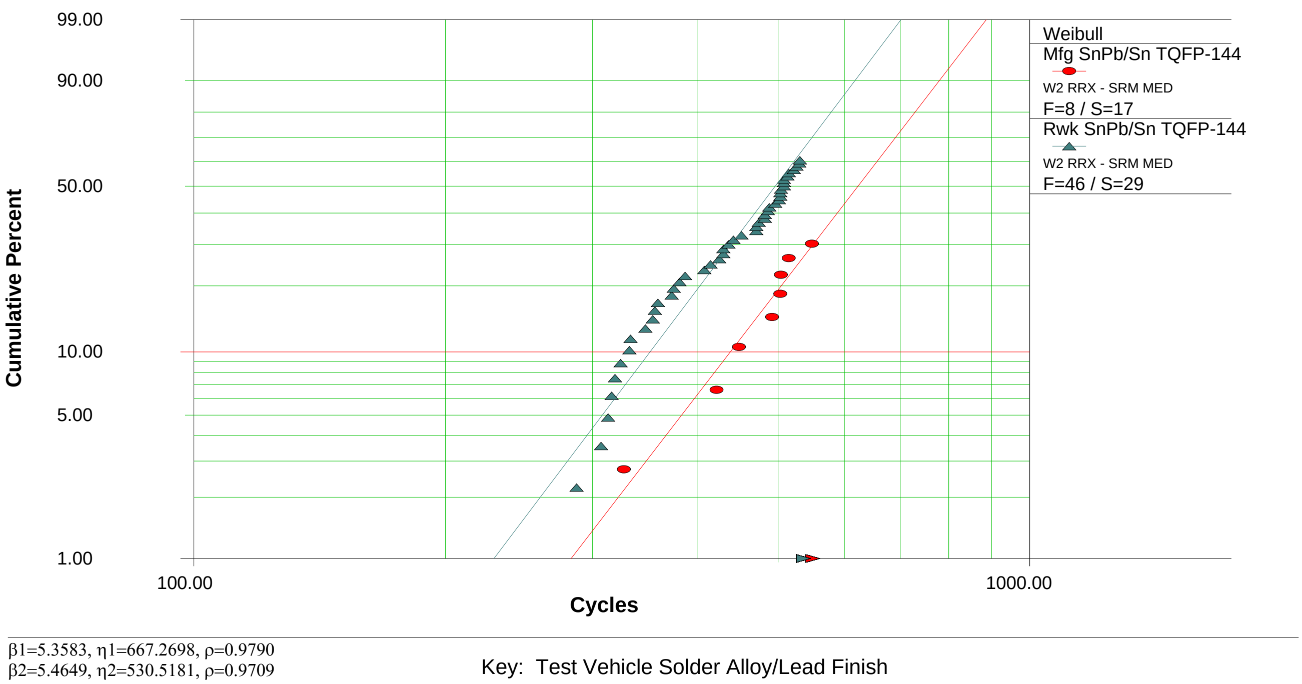

Figure 101 Comparison of Tin-Lead Soldered Tin TQFP-144 Components on Manufacture and Rework Test Vehicles

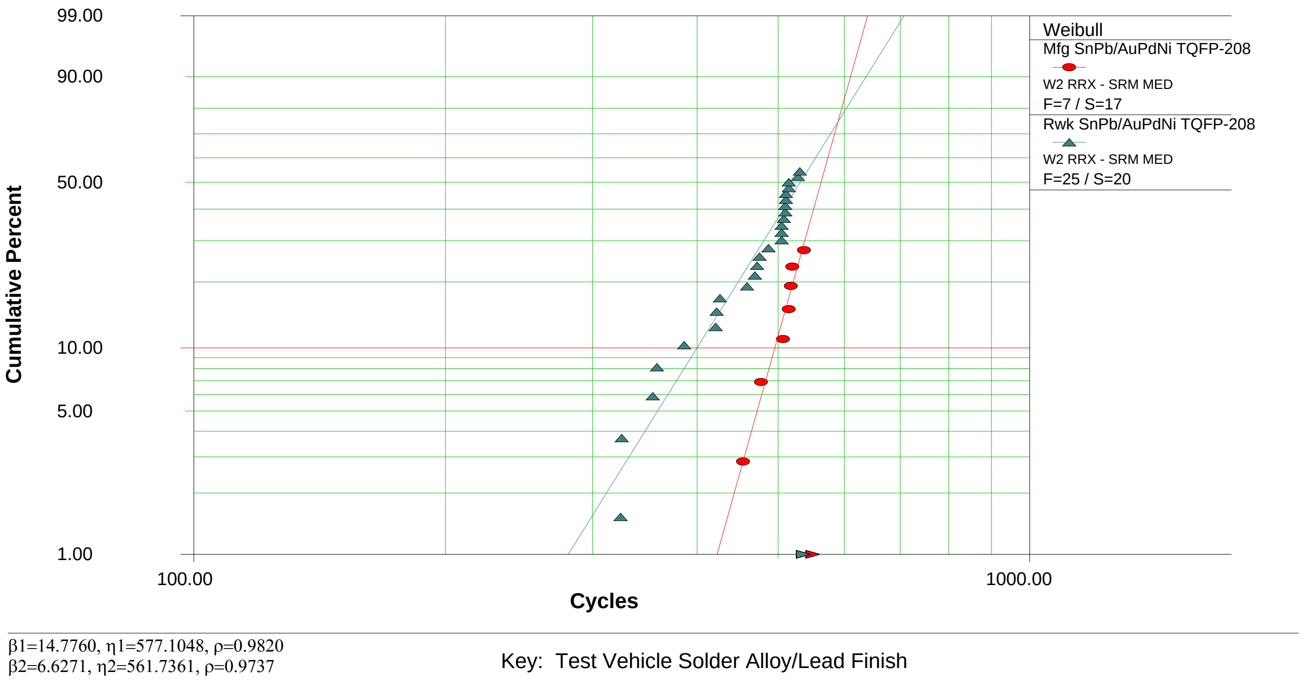

Figure 102 Comparison of Tin-Lead Soldered Gold-Palladium-Nickel TQFP-208 Components on Manufacture and Rework Test Vehicles

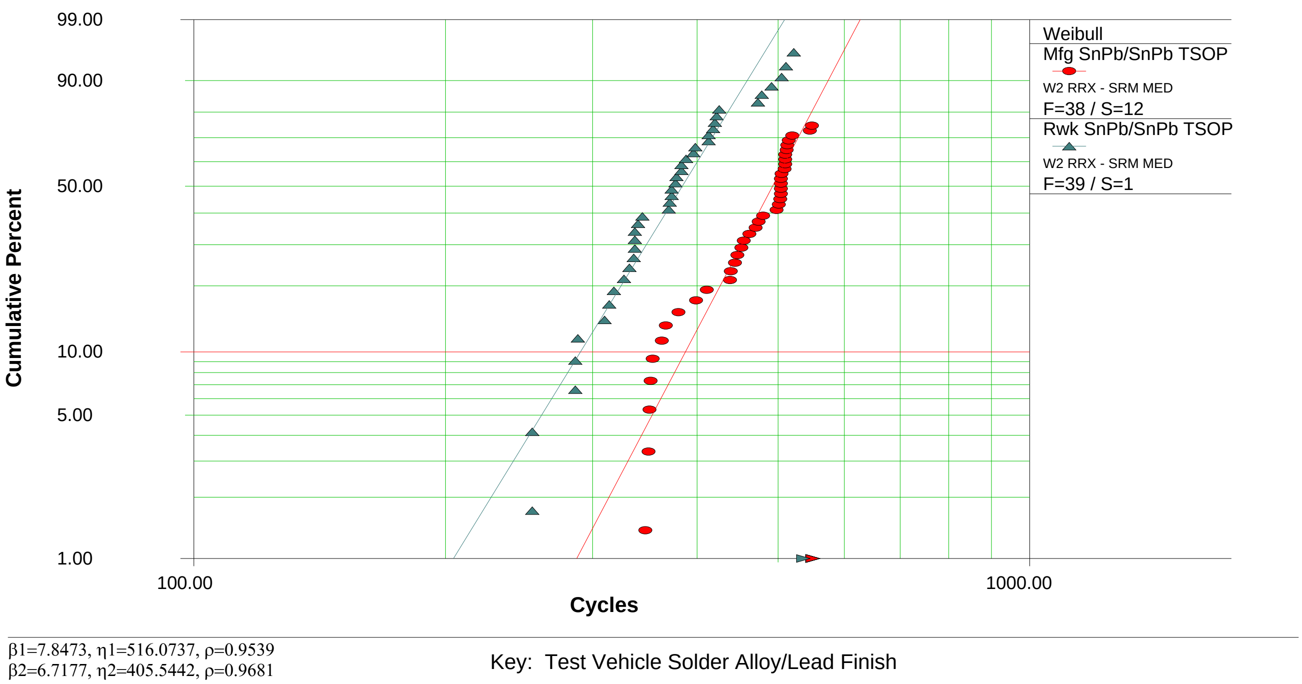

Figure 103 Comparison of Tin-Lead Soldered TSOP-50 Components on Manufacture and Rework Test Vehicles

Statistical Analysis

Additional statistical analysis was conducted using Statgraphics version 5 software. Variance component analysis was conducted and the software results are shown in Table 19 and graphically presented in Figure 104. The analysis of variance table divides the variance of the cycles to failure into 5 components, one for each factor. Each factor after the first is nested in the one above. The goal of such an analysis is usually to estimate the amount of variability contributed by each of the factors, called the variance components. The factors included: solder paste; lead finish; component location along the x-axis (long axis of the board); component location along the y-axis; component type; plus unexplained error. The analysis shows that solder joint reliability was influenced by the choice of solder paste, but it was probably less than either the choice of component or random noise. The analysis was only an approximate estimate since censored values (samples that did not fail) were left at their last measured cycle. The random noise would include other factors not included in the experiment or analysis. The analysis further shows that the influence due to lead finish or component location is very low.

Table 19 Variance Components Analysis

Source	Sum of Squares	Df	Mean Square	Var. Comp.	Percent
TOTAL (Corrected)	1.31013E7	821			
Component	5.10579E6	6	850964	5985.63	35.02
Lead Finish	748189	5	149638	354.155	2.07
Solder Alloy	2.30537E6	18	128076	4182.98	24.48
X	1.152E6	106	10867.9	1028.77	6.02
Y	151403	29	5220.78	0.0	0.0
ERROR	3.63852E6	567	5538.08	5538.08	32.41

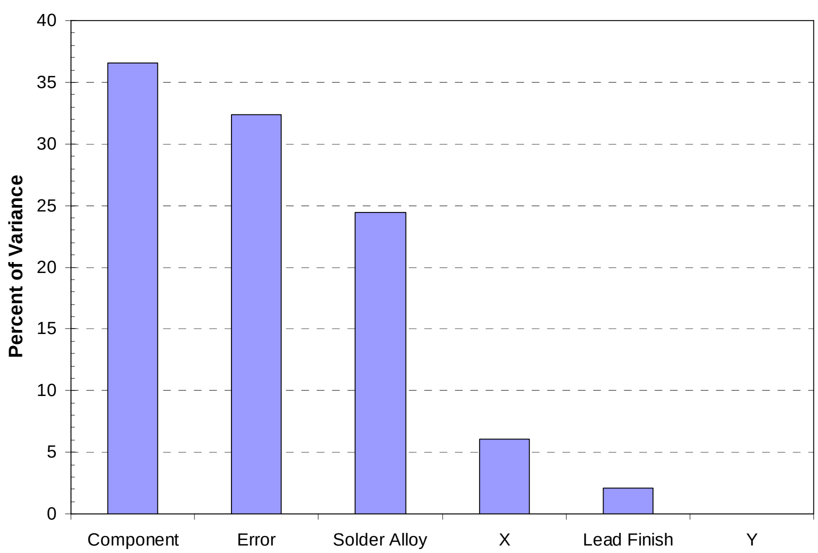

Figure 104 Chart of Variance Components Analysis

Overall, the component type had the greatest effect on solder joint reliability performance. The plated-through-hole components proved to be more reliable than the surface mount technology components. The relative ranking of the different component types soldered with tin-lead solder is shown in Figure 105. The plated-through holes, PDIP-20 and PLCC-20 components performed the best. The CSP-100 and hybrid components had the worst solder joint reliability.

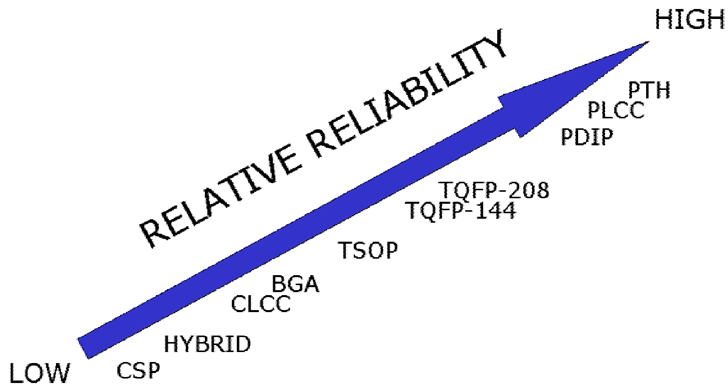

Figure 105 Relative Reliability of Components for Tin-Lead Solder on Manufacture and Hybrid Test Vehicles

The relative ranking of the different component types and finishes soldered with tin-silver-copper alloy is shown in Figure 106. The relative ranking of the different component types and finishes soldered with tin-silver-copper-bismuth alloy is shown in Figure 107. The effect of tin-lead contamination on solder joint reliability is evident as the tin-lead finish components are generally less reliable than the corresponding lead-free finish components.

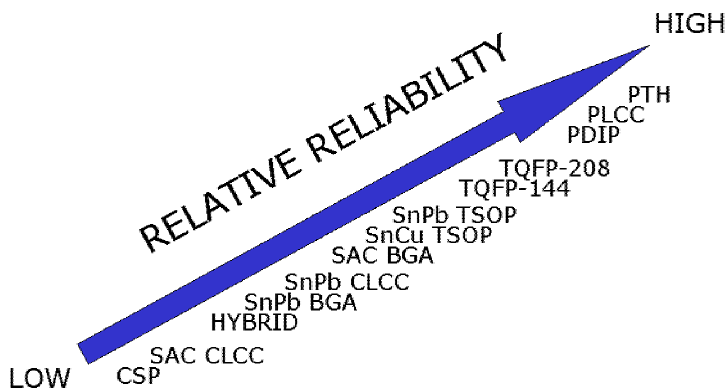

Figure 106 Relative Reliability of Components for Tin-Silver-Copper Solder on Manufacture and Hybrid Test Vehicles

The solder alloy had a major secondary effect on solder joint reliability. In general, tin-silver-copper soldered components were less reliable than the tin-lead soldered controls. In general, tin-silver-copper-bismuth soldered components were more reliable than the tin-lead soldered controls with the exceptions of tin-lead BGA-225 components, tin-lead TSOP-50 components and reworked components due to the lead contamination in the solder joints.

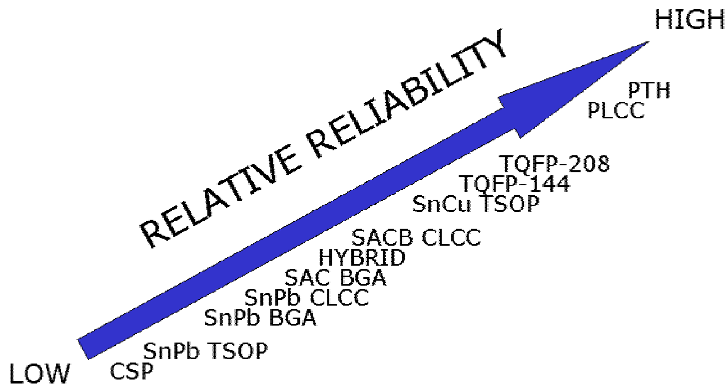

Figure 107 Relative Reliability of Components for Tin-Silver-Copper-Bismuth Solder on Manufacture and Hybrid Test Vehicles

The solder alloy had a major secondary effect on solder joint reliability. The relative reliability of the lead-free solder alloys compared to tin-lead controls is shown in Figure 108. The graph summarizes the N(63%) values for the different component types, component finishes and solder alloys compared to the tin-lead controls. The shaded area of the graph shows the 95% confidence intervals for the tin-lead controls. Data within the bounded area indicate the lead-free soldered components have similar performance to the tin-lead controls. Data outside the bounded area indicate the lead-free soldered components have significantly different (better or worse) performance compared to the tin-lead controls. In general, tin-silver-copper soldered components had a higher failure rate than the tin-lead soldered controls. The components are listed from low to higher reliability. In general, tin-silver-copper-bismuth soldered components were more reliable than the tin-lead soldered controls with the exceptions of CSP-100 components, tin-lead BGA-225 components, tin-lead TSOP-50 components and reworked components due to the lead contamination in the solder joints.

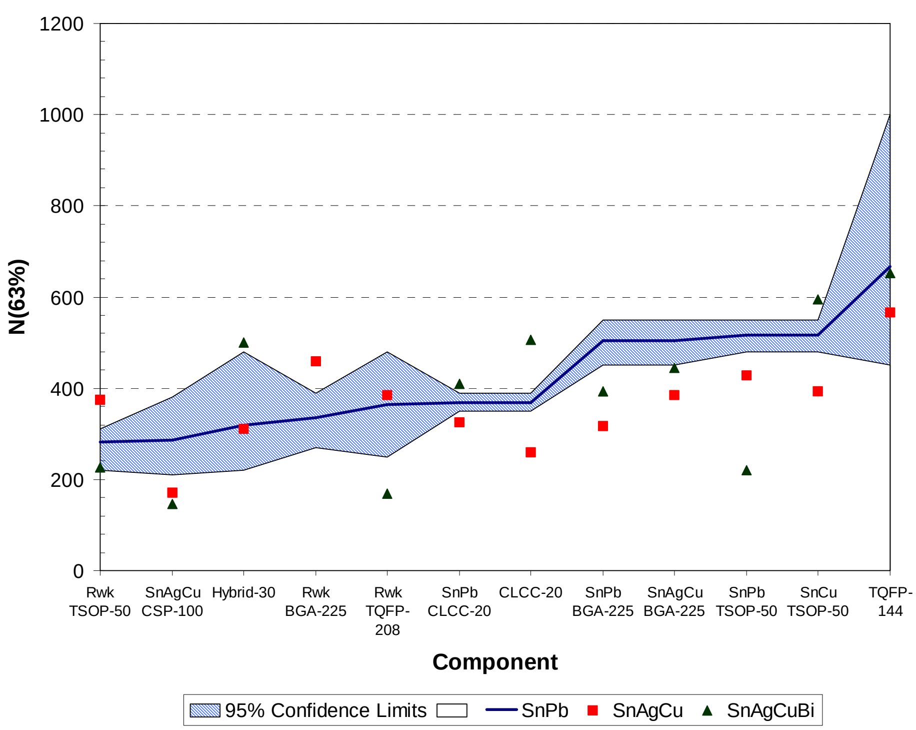

Figure 108 Relative Reliability of Lead-Free Solders Compared to Tin-Lead Baseline Based on N(63%)

The relative reliability of the lead-free solder alloys compared to the tin-lead controls based on N(10%) is shown in Figure 109 to aid in determining which lead-free solders met the JTP acceptance criteria.

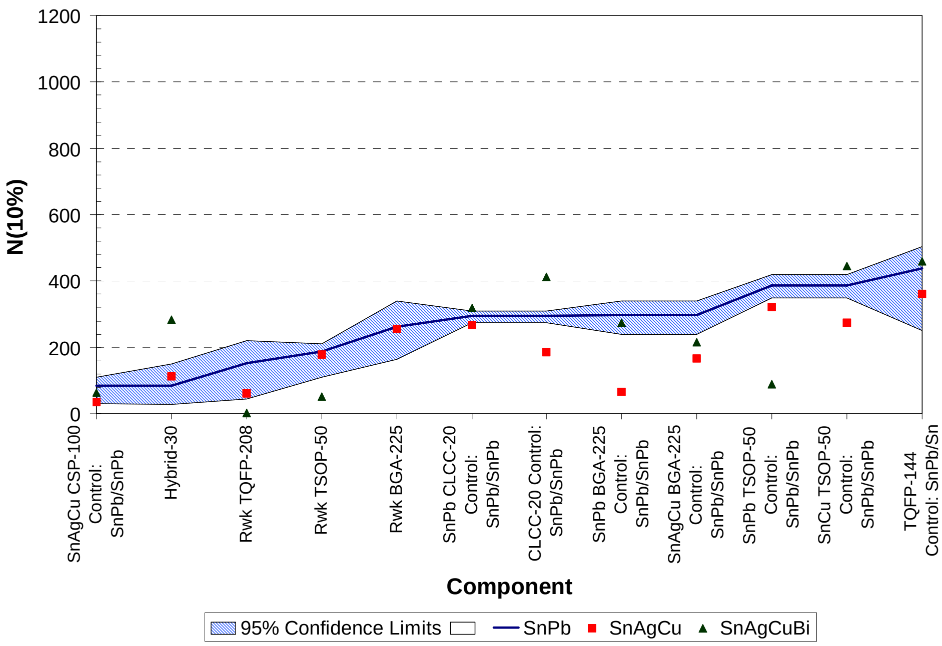

Figure 109 Relative Reliability of Lead-Free Solders Compared to Tin-Lead Controls Based on N(10%)

Only seven lead-free soldered samples met the JTP acceptance criteria of lead-free solder joint reliability better than or equal to eutectic tin-lead controls at ten percent Weibull cumulative failures. The seven samples are tabulated in Table 20. Those samples include tin-silver-copper-bismuth soldered CLCC-20 components, TQFP-144 components and tin-copper TSOP-50 components on manufactured test vehicles, and tin-silver-copper-bismuth hybrid-30 components on hybrid test boards. The only tin-silver-copper soldered components that met the JTP acceptance criteria were the reworked BGA-225 on rework test vehicles and tin-silver-copper hybrid-30 on hybrid test vehicles. There were not enough failures of the more robust plated-through-hole parts to compare the performance of the tin-silver-copper and tin-copper solder alloys used in wave solder.

Table 20 Component Type, Component Finish, Solder Alloy and Test Vehicle Type Combinations Meeting the JTP Acceptance Criteria

Test Vehicle	Solder Alloy	Component Finish	Component Type
Manufacture	SnAgCuBi	SnAgCuBi	CLCC-20
Manufacture	SnAgCuBi	SnPb	CLCC-20
Manufacture	SnAgCuBi	Sn	TQFP-144
Manufacture	SnAgCuBi	SnCu	TSOP-50
Rework	N/A	SnAgCu	BGA-225
Hybrid	SnAgCuBi	SnAgCuBi	Hybrid-30
Hybrid	SnAgCu	SnAgCu	Hybrid-30

The component location on the test vehicle in the x-axis (along the long dimension of the board) and lead finish had minor effect on solder joint reliability. The component location relative to the y-axis had no effect on solder joint reliability.

Conclusions

Only seven lead-free soldered components met the JTP acceptance criteria. Five of the components were soldered with tin-silver-copper-bismuth. The remaining two components were soldered with tin-silver-copper.

Overall, the component type had the greatest effect on solder joint reliability performance. The plated-through-hole components proved to be more reliable than the surface mount technology components.

The solder alloy had a major secondary effect on solder joint reliability. In general, tin-silver-copper-bismuth soldered components were more reliable than the tin-lead soldered controls with the exceptions of tin-lead BGA-225 components, tin-lead TSOP-50 components and reworked components due to the lead contamination in the solder joints. In general, tin-silver-copper soldered components were less reliable than the tin-lead soldered controls. The lower reliability of the tin-silver-copper solder joints does not necessarily rule out the use of tin-silver-copper solder alloy on military electronics based on these results.

Overall, component location on the board and component lead finish had minor effect on solder joint reliability.

The effect of tin-lead contamination on the lead-free solder alloy reliability was mixed. For tin-silver-copper, the effect of tin-lead contamination was minimal. There were small improvements in solder joint reliability on TSOP-50 components on manufacture test vehicles and reworked BGA-225 components on rework test vehicles. There was a slight degradation in solder joint reliability on BGA-225 on manufacture test vehicles and reworked TQFP-208 and reworked TSOP-50 on rework test vehicles.

For tin-silver-copper-bismuth solder alloy, the effect of tin-lead contamination was much greater. There was no effect on solder joint reliability on BGA-225 on manufacture test vehicles. There was a slight degradation in solder joint reliability on CLCC-20 components on manufacture test vehicles. There was major degradation in solder joint reliability on TSOP-50 components on manufacture test vehicles and reworked TQFP-208 components and reworked TSOP-50 components on rework test vehicles. The amount of solder joint reliability degradation appears to be inversely proportional to the amount of tin-lead contamination in the solder joint. Therefore, soldering with tin-silver-copper-bismuth solder requires precise control of the lead contamination. The level of control required may not be available to military depots and might pose an unacceptable risk to weapons systems. Therefore, the use of tin-silver-copper-bismuth solder may be precluded on some or all military electronics even though the alloy exhibits improved resistance to low cycle fatigue over the tin-silver-copper alloy.

In general, reworked components were less reliable than the unreworked components. This is especially true with reworked leaded components including the TQFP-208, PDIP-20 and TSOP-50 components. The exception was the reworked BGA-225 components. The reworked tin-silver-copper BGA-225 components were more reliable than even the tin-silver-copper soldered tin-silver-copper BGA-225 components on the manufacture test vehicles. This suggests the reworked BGA-225 components experienced higher processing temperatures from the hot air rework process which may have resulted in improved alloying between the component ball and residual tin-lead solder on the board pads (no additional solder was added in BGA-225 rework).

When comparing the performance of components on manufacture and rework test vehicles, the higher glass transition temperature laminate and immersion silver board surface finish of the manufacture test vehicle appear to enhance the reliability of the solder joints.

Recommendations

The results of the CET should be compared to the results of the pure thermal cycling and vibration tests executed in the JCAA/JG-PP Lead-Free Solder Project. If the general results and conclusions are similar, then the CET might be a useful tool to accelerate the testing of future lead-free solder alloys.

From this test program, it appears the selection of component type and lead-free solder combinations should be considered as critical factors when considering a conversion to lead-free solder assembly, especially for surface mount technology design configurations.

Further investigation in terms of destructive physical analysis and microsection analysis are recommended for the reworked components and in particular the lead-free solder reworked U3 and U57 TQFP-208 components.

Since this test evaluated only solder joint reliability, additional tests must be done to validate assembly reliability with respect to the effect of higher reflow temperatures on printed circuit boards and functional integrated circuits. Additional testing on functional military electronics at the system level is warranted.

References

IPC-9701. Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments. January 2002.

IPC/EIA J-STD-001. Requirements for Soldered Electrical and Electronic Assemblies. March 2000.

IPC-SM-785. Guidelines for Accelerated Reliability Testing of Surface Mount Solder Attachments. November 1992.

Joint Group on Pollution Prevention. Joint Test Protocol J-01-EM-026-P1 for Validation of Alternatives to Eutectic Tin-Lead Solders used in Manufacturing and Rework of Printed Wiring Assemblies. April 2004.

MIL-STD-810F, Method 520.2. Temperature, Humidity, Vibration, and Altitude.

Appendixes

Appendix A: Manufacture Assembly Raw Test Data

Appendix B: Rework Assembly Raw Test Data

Appendix C: Hybrid Assembly Raw Test Data

Appendix A: Manufacture Assembly Raw Test Data

Table 21 Manufacture Assembly Raw Data

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
139	1	U1	TQFP-144	Sn	SACB	353		
139	2	U26	TSOP-50	SnPb	SACB	156		X
139	3	U41	TQFP-144	Sn	SACB	502		
139	4	U9	CLCC-20	SnPb	SACB	316		X
139	5	U27	PLCC-20	Sn	SACB			
139	6	U18	BGA-225	SAC	SACB	355		
139	7	U39	TSOP-50	SnCu	SACB			
139	8	U56	BGA-225	SnPb	SACB	349		
139	9	U40	TSOP-50	SnPb	SACB	272		X
139	10	U3	TQFP-208	AuPdNi	SACB			
139	11	U13	CLCC-20	SnPb	SACB	352		X
139	13	U57	TQFP-208	AuPdNi	SACB	221		
139	14	U14	CLCC-20	SACB	SACB	475		
139	15	U15	PLCC-20	Sn	SACB			
139	16	U25	TSOP-50	SnCu	SACB			
139	19	U58	TQFP-144	Sn	SACB			
139	20	U12	TSOP-50	SnCu	SACB	413		
139	22	U55	BGA-225	SAC	SACB	394		
139	23	U17	CLCC-20	SACB	SACB	437		
139	24	U2	BGA-225	SnPb	SACB	291		
139	25	U31	TQFP-208	AuPdNi	SACB			
139	26	U45	CLCC-20	SACB	SACB	469		
139	27	U46	CLCC-20	SnPb	SACB	392		X
139	28	U47	PLCC-20	Sn	SACB			
139	30	U24	TSOP-50	SnPb	SACB	159		X
139	32	U4	BGA-225	SAC	SACB	355		
139	33	U43	BGA-225	SAC	SACB	504		
139	34	U20	TQFP-144	Sn	SACB			
139	35	U21	BGA-225	SnPb	SACB	450		
139	36	U44	BGA-225	SnPb	SACB	330		
139	37	U61	TSOP-50	SnCu	SACB	504		
139	38	U54	PLCC-20	Sn	SACB			
139	39	U48	TQFP-208	AuPdNi	SACB			
139	40	U7	TQFP-144	Sn	SACB	479		
139	41	U22	CLCC-20	SnPb	SACB	353		X
139	42	U16	TSOP-50	SnPb	SACB	92		X
139	44	U11	PDIP-20	Sn	SnCu			
139	45	U30	PDIP-20	Sn	SnCu			
139	46	U35	PDIP-20	AuPdNi	SnCu			
139	47	U38	PDIP-20	Sn	SnCu			
139	48	U49	PDIP-20	AuPdNi	SnCu			
139	49	U51	PDIP-20	Sn	SnCu			
139	50	U59	PDIP-20	AuPdNi	SnCu			
139	51	U63	PDIP-20	Sn	SnCu	51	Broken wire	
139	52	U5	BGA-225	SnPb	SACB	353		
139	53	U6	BGA-225	SAC	SACB	164		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
139	54	U34	TQFP-208	AuPdNi	SACB			
139	55	U52	CLCC-20	SACB	SACB	430		
139	56	U53	CLCC-20	SnPb	SACB	482		
139	57	U62	TSOP-50	SnPb	SACB	312		X
139	59	U10	CLCC-20	SACB	SACB	483		
139	60	U28	PLCC-20	Sn	SACB			
139	61	U29	TSOP-50	SnCu	SACB			
139	62	U8	PDIP-20	AuPdNi	SnCu			
139	63	U23	PDIP-20	AuPdNi	SnCu			
139	64	PTH's	PTH's		SACB			
34	65	U1	TQFP-144	Sn	SnPb	492		
34	66	U26	TSOP-50	SnPb	SnPb	509		
34	67	U41	TQFP-144	Sn	SnPb			
34	68	U9	CLCC-20	SnPb	SnPb	353		X
34	69	U27	PLCC-20	Sn	SnPb			
34	70	U18	BGA-225	SnPb	SnPb	480		
34	71	U39	TSOP-50	SnPb	SnPb	520		
34	72	U56	BGA-225	SnPb	SnPb	499		
34	73	U40	TSOP-50	SnPb	SnPb	510		
34	74	U3	TQFP-208	AuPdNi	SnPb	537		
34	75	U13	CLCC-20	SnPb	SnPb	297		X
34	77	U57	TQFP-208	AuPdNi	SnPb			
34	78	U14	CLCC-20	SnPb	SnPb	353		X
34	79	U15	PLCC-20	Sn	SnPb			
34	80	U25	TSOP-50	SnPb	SnPb	447		
34	83	U58	TQFP-144	Sn	SnPb			
34	84	U12	TSOP-50	SnPb	SnPb	470		
34	86	U55	BGA-225	SnPb	SnPb	539		
34	87	U17	CLCC-20	SnPb	SnPb	415		X
34	88	U2	BGA-225	SnPb	SnPb	351		
34	89	U31	TQFP-208	AuPdNi	SnPb	515		
34	90	U45	CLCC-20	SnPb	SnPb	352		X
34	91	U46	CLCC-20	SnPb	SnPb	352		X
34	92	U47	PLCC-20	Sn	SnPb			
34	94	U24	TSOP-50	SnPb	SnPb	439		X
34	96	U4	BGA-225	SnPb	SnPb	454		
34	97	U43	BGA-225	SnPb	SnPb	492		
34	98	U20	TQFP-144	Sn	SnPb			
34	99	U21	BGA-225	SnPb	SnPb	502		
34	100	U44	BGA-225	SnPb	SnPb	476		
34	101	U61	TSOP-50	SnPb	SnPb	504		
34	102	U54	PLCC-20	Sn	SnPb			
34	103	U48	TQFP-208	AuPdNi	SnPb			
34	104	U7	TQFP-144	Sn	SnPb	449		
34	105	U22	CLCC-20	SnPb	SnPb	481		X
34	106	U16	TSOP-50	SnPb	SnPb	474		
34	108	U11	PDIP-20	Sn	SnPb			
34	109	U30	PDIP-20	Sn	SnPb			
34	110	U35	PDIP-20	AuPdNi	SnPb			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
34	111	U38	PDIP-20	Sn	SnPb			
34	112	U49	PDIP-20	AuPdNi	SnPb	51		
34	113	U51	PDIP-20	Sn	SnPb			
34	114	U59	PDIP-20	AuPdNi	SnPb	11		
34	115	U63	PDIP-20	Sn	SnPb			
34	116	U5	BGA-225	SnPb	SnPb	416		
34	117	U6	BGA-225	SnPb	SnPb	503		
34	118	U34	TQFP-208	AuPdNi	SnPb			
34	119	U52	CLCC-20	SnPb	SnPb	353		X
34	120	U53	CLCC-20	SnPb	SnPb	367		X
34	121	U62	TSOP-50	SnPb	SnPb	504		
34	123	U10	CLCC-20	SnPb	SnPb	368		X
34	124	U28	PLCC-20	Sn	SnPb			
34	125	U29	TSOP-50	SnPb	SnPb	503		
34	126	U8	PDIP-20	AuPdNi	SnPb			
34	127	U23	PDIP-20	AuPdNi	SnPb			
34	128	PTH's	PTH's		SnPb			
142	129	U1	TQFP-144	Sn	SACB	29	Broken wire	
142	130	U26	TSOP-50	SnPb	SACB	202		X
142	131	U41	TQFP-144	Sn	SACB	525		
142	132	U9	CLCC-20	SnPb	SACB	338		X
142	133	U27	PLCC-20	Sn	SACB			
142	134	U18	BGA-225	SAC	SACB	389		
142	135	U39	TSOP-50	SnCu	SACB			
142	136	U56	BGA-225	SnPb	SACB	351		
142	137	U40	TSOP-50	SnPb	SACB	350		X
142	138	U3	TQFP-208	AuPdNi	SACB			
142	139	U13	CLCC-20	SnPb	SACB	302		X
142	141	U57	TQFP-208	AuPdNi	SACB			
142	142	U14	CLCC-20	SACB	SACB	501		
142	143	U15	PLCC-20	Sn	SACB			
142	144	U25	TSOP-50	SnCu	SACB	524		
142	147	U58	TQFP-144	Sn	SACB	530		
142	148	U12	TSOP-50	SnCu	SACB	475		
142	150	U55	BGA-225	SAC	SACB	1		
142	151	U17	CLCC-20	SACB	SACB	1		
142	152	U2	BGA-225	SnPb	SACB	311		
142	153	U31	TQFP-208	AuPdNi	SACB	536		
142	154	U45	CLCC-20	SACB	SACB	435		
142	155	U46	CLCC-20	SnPb	SACB	435		X
142	156	U47	PLCC-20	Sn	SACB			
142	158	U24	TSOP-50	SnPb	SACB	178		
142	160	U4	BGA-225	SAC	SACB	346		
142	161	U43	BGA-225	SAC	SACB	354		
142	162	U20	TQFP-144	Sn	SACB	501		
142	163	U21	BGA-225	SnPb	SACB	351		
142	164	U44	BGA-225	SnPb	SACB	351		
142	165	U61	TSOP-50	SnCu	SACB	482		X
142	166	U54	PLCC-20	Sn	SACB			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
142	167	U48	TQFP-208	AuPdNi	SACB	511		
142	168	U7	TQFP-144	Sn	SACB	467		
142	169	U22	CLCC-20	SnPb	SACB	353		X
142	170	U16	TSOP-50	SnPb	SACB	133		X
142	172	U11	PDIP-20	Sn	SnCu			
142	173	U30	PDIP-20	Sn	SnCu			
142	174	U35	PDIP-20	AuPdNi	SnCu	317		
142	175	U38	PDIP-20	Sn	SnCu			
142	176	U49	PDIP-20	AuPdNi	SnCu			
142	177	U51	PDIP-20	Sn	SnCu			
142	178	U59	PDIP-20	AuPdNi	SnCu			
142	179	U63	PDIP-20	Sn	SnCu			
142	180	U5	BGA-225	SnPb	SACB	311		
142	181	U6	BGA-225	SAC	SACB	356		
142	182	U34	TQFP-208	AuPdNi	SACB	423		
142	183	U52	CLCC-20	SACB	SACB	501		
142	184	U53	CLCC-20	SnPb	SACB	379		
142	185	U62	TSOP-50	SnPb	SACB	222		X
142	187	U10	CLCC-20	SACB	SACB	449		
142	188	U28	PLCC-20	Sn	SACB			
142	189	U29	TSOP-50	SnCu	SACB	367		
142	190	U8	PDIP-20	AuPdNi	SnCu			
142	191	U23	PDIP-20	AuPdNi	SnCu			
142	192	PTH's	PTH's		SACB			
103	193	U1	TQFP-144	Sn	SAC	389		
103	194	U26	TSOP-50	SnPb	SAC	373		
103	195	U41	TQFP-144	Sn	SAC			
103	196	U9	CLCC-20	SnPb	SAC	307		X
103	197	U27	PLCC-20	Sn	SAC			
103	198	U18	BGA-225	SAC	SAC	320		
103	199	U39	TSOP-50	SnCu	SAC	406		X
103	200	U56	BGA-225	SnPb	SAC	0		
103	201	U40	TSOP-50	SnPb	SAC	488		
103	202	U3	TQFP-208	AuPdNi	SAC			
103	203	U13	CLCC-20	SnPb	SAC	295		X
103	205	U57	TQFP-208	AuPdNi	SAC			
103	206	U14	CLCC-20	SAC	SAC	198		X
103	207	U15	PLCC-20	Sn	SAC			
103	208	U25	TSOP-50	SnCu	SAC	434		X
103	211	U58	TQFP-144	Sn	SAC			
103	212	U12	TSOP-50	SnCu	SAC	311		
103	214	U55	BGA-225	SAC	SAC	363		
103	215	U17	CLCC-20	SAC	SAC	256		X
103	216	U2	BGA-225	SnPb	SAC	218		
103	217	U31	TQFP-208	AuPdNi	SAC			
103	218	U45	CLCC-20	SAC	SAC	299		X
103	219	U46	CLCC-20	SnPb	SAC	361		X
103	220	U47	PLCC-20	Sn	SAC			
103	222	U24	TSOP-50	SnPb	SAC	409		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
103	224	U4	BGA-225	SAC	SAC	334		
103	225	U43	BGA-225	SAC	SAC	453		
103	226	U20	TQFP-144	Sn	SAC	457		
103	227	U21	BGA-225	SnPb	SAC	394		
103	228	U44	BGA-225	SnPb	SAC	213		
103	229	U61	TSOP-50	SnCu	SAC	482		
103	230	U54	PLCC-20	Sn	SAC			
103	231	U48	TQFP-208	AuPdNi	SAC			
103	232	U7	TQFP-144	Sn	SAC	362		
103	233	U22	CLCC-20	SnPb	SAC	349		
103	234	U16	TSOP-50	SnPb	SAC	398		
103	236	U11	PDIP-20	Sn	SAC			
103	237	U30	PDIP-20	Sn	SAC			
103	238	U35	PDIP-20	AuPdNi	SAC			
103	239	U38	PDIP-20	Sn	SAC			
103	240	U49	PDIP-20	AuPdNi	SAC			
103	241	U51	PDIP-20	Sn	SAC			
103	242	U59	PDIP-20	AuPdNi	SAC			
103	243	U63	PDIP-20	Sn	SAC			
103	244	U5	BGA-225	SnPb	SAC	330		
103	245	U6	BGA-225	SAC	SAC	162		
103	246	U34	TQFP-208	AuPdNi	SAC			
103	247	U52	CLCC-20	SAC	SAC	302		X
103	248	U53	CLCC-20	SnPb	SAC	304		
103	249	U62	TSOP-50	SnPb	SAC	448		
103	251	U10	CLCC-20	SAC	SAC	201		X
103	252	U28	PLCC-20	Sn	SAC			
103	253	U29	TSOP-50	SnCu	SAC	367		
103	254	U8	PDIP-20	AuPdNi	SAC			
103	255	U23	PDIP-20	AuPdNi	SAC			
103	256	PTH's	PTH's		SAC			
32	257	U1	TQFP-144	Sn	SnPb	422		
32	258	U26	TSOP-50	SnPb	SnPb	347		
32	259	U41	TQFP-144	Sn	SnPb			
32	260	U9	CLCC-20	SnPb	SnPb	350		X
32	261	U27	PLCC-20	Sn	SnPb			
32	262	U18	BGA-225	SnPb	SnPb	306		
32	263	U39	TSOP-50	SnPb	SnPb	380		
32	264	U56	BGA-225	SnPb	SnPb	370		
32	265	U40	TSOP-50	SnPb	SnPb	363		
32	266	U3	TQFP-208	AuPdNi	SnPb	454		
32	267	U13	CLCC-20	SnPb	SnPb	259		X
32	269	U57	TQFP-208	AuPdNi	SnPb	518		
32	270	U14	CLCC-20	SnPb	SnPb	330		X
32	271	U15	PLCC-20	Sn	SnPb			
32	272	U25	TSOP-50	SnPb	SnPb	350		X
32	275	U58	TQFP-144	Sn	SnPb			
32	276	U12	TSOP-50	SnPb	SnPb	367		
32	278	U55	BGA-225	SnPb	SnPb	353		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
32	279	U17	CLCC-20	SnPb	SnPb	326		X
32	280	U2	BGA-225	SnPb	SnPb	210		
32	281	U31	TQFP-208	AuPdNi	SnPb			
32	282	U45	CLCC-20	SnPb	SnPb	313		X
32	283	U46	CLCC-20	SnPb	SnPb	305		X
32	284	U47	PLCC-20	Sn	SnPb			
32	286	U24	TSOP-50	SnPb	SnPb	352		X
32	288	U4	BGA-225	SnPb	SnPb	311		
32	289	U43	BGA-225	SnPb	SnPb	175		
32	290	U20	TQFP-144	Sn	SnPb	503		
32	291	U21	BGA-225	SnPb	SnPb	351		
32	292	U44	BGA-225	SnPb	SnPb	436		
32	293	U61	TSOP-50	SnPb	SnPb	455		
32	294	U54	PLCC-20	Sn	SnPb			
32	295	U48	TQFP-208	AuPdNi	SnPb			
32	296	U7	TQFP-144	Sn	SnPb	515		
32	297	U22	CLCC-20	SnPb	SnPb	351		X
32	298	U16	TSOP-50	SnPb	SnPb	480		
32	300	U11	PDIP-20	Sn	SnPb			
32	301	U30	PDIP-20	Sn	SnPb			
32	302	U35	PDIP-20	AuPdNi	SnPb			
32	303	U38	PDIP-20	Sn	SnPb			
32	304	U49	PDIP-20	AuPdNi	SnPb			
32	305	U51	PDIP-20	Sn	SnPb			
32	306	U59	PDIP-20	AuPdNi	SnPb			
32	307	U63	PDIP-20	Sn	SnPb			
32	308	U5	BGA-225	SnPb	SnPb	303		
32	309	U6	BGA-225	SnPb	SnPb	316		
32	310	U34	TQFP-208	AuPdNi	SnPb			
32	311	U52	CLCC-20	SnPb	SnPb	352		X
32	312	U53	CLCC-20	SnPb	SnPb	353		X
32	313	U62	TSOP-50	SnPb	SnPb	452		
32	315	U10	CLCC-20	SnPb	SnPb	306		X
32	316	U28	PLCC-20	Sn	SnPb			
32	317	U29	TSOP-50	SnPb	SnPb	354		
32	318	U8	PDIP-20	AuPdNi	SnPb			
32	319	U23	PDIP-20	AuPdNi	SnPb			
32	320	PTH's	PTH's		SnPb			
141	321	U1	TQFP-144	Sn	SACB			
141	322	U26	TSOP-50	SnPb	SACB	131		X
141	323	U41	TQFP-144	Sn	SACB			
141	324	U9	CLCC-20	SnPb	SACB	351		
141	325	U27	PLCC-20	Sn	SACB			
141	326	U18	BGA-225	SAC	SACB	302		
141	327	U39	TSOP-50	SnCu	SACB			
141	328	U56	BGA-225	SnPb	SACB	484		
141	329	U40	TSOP-50	SnPb	SACB	278		X
141	330	U3	TQFP-208	AuPdNi	SACB			
141	331	U13	CLCC-20	SnPb	SACB	368		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
141	333	U57	TQFP-208	AuPdNi	SACB			
141	334	U14	CLCC-20	SACB	SACB	458		
141	335	U15	PLCC-20	Sn	SACB			
141	336	U25	TSOP-50	SnCu	SACB			
141	339	U58	TQFP-144	Sn	SACB			
141	340	U12	TSOP-50	SnCu	SACB			
141	342	U55	BGA-225	SAC	SACB			
141	343	U17	CLCC-20	SACB	SACB			
141	344	U2	BGA-225	SnPb	SACB	223		
141	345	U31	TQFP-208	AuPdNi	SACB			
141	346	U45	CLCC-20	SACB	SACB	518		
141	347	U46	CLCC-20	SnPb	SACB	501		
141	348	U47	PLCC-20	Sn	SACB			
141	350	U24	TSOP-50	SnPb	SACB	212		
141	352	U4	BGA-225	SAC	SACB	352		
141	353	U43	BGA-225	SAC	SACB	471		
141	354	U20	TQFP-144	Sn	SACB			
141	355	U21	BGA-225	SnPb	SACB	352		
141	356	U44	BGA-225	SnPb	SACB	353		
141	357	U61	TSOP-50	SnCu	SACB			
141	358	U54	PLCC-20	Sn	SACB			
141	359	U48	TQFP-208	AuPdNi	SACB			
141	360	U7	TQFP-144	Sn	SACB			
141	361	U22	CLCC-20	SnPb	SACB	352		X
141	362	U16	TSOP-50	SnPb	SACB	112		X
141	364	U11	PDIP-20	Sn	SnCu			
141	365	U30	PDIP-20	Sn	SnCu			
141	366	U35	PDIP-20	AuPdNi	SnCu			
141	367	U38	PDIP-20	Sn	SnCu			
141	368	U49	PDIP-20	AuPdNi	SnCu			
141	369	U51	PDIP-20	Sn	SnCu			
141	370	U59	PDIP-20	AuPdNi	SnCu			
141	371	U63	PDIP-20	Sn	SnCu			
141	372	U5	BGA-225	SnPb	SACB	301		
141	373	U6	BGA-225	SAC	SACB	188		
141	374	U34	TQFP-208	AuPdNi	SACB			
141	375	U52	CLCC-20	SACB	SACB			
141	376	U53	CLCC-20	SnPb	SACB	457		
141	377	U62	TSOP-50	SnPb	SACB	218		X
141	379	U10	CLCC-20	SACB	SACB			
141	380	U28	PLCC-20	Sn	SACB			
141	381	U29	TSOP-50	SnCu	SACB	517		
141	382	U8	PDIP-20	AuPdNi	SnCu			
141	383	U23	PDIP-20	AuPdNi	SnCu			
141	384	PTH's	PTH's		SACB			
100	385	U1	TQFP-144	Sn	SAC			
100	386	U26	TSOP-50	SnPb	SAC	367		
100	387	U41	TQFP-144	Sn	SAC	527		
100	388	U9	CLCC-20	SnPb	SAC	347		X

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
100	389	U27	PLCC-20	Sn	SAC			
100	390	U18	BGA-225	SAC	SAC	376		
100	391	U39	TSOP-50	SnCu	SAC	506		
100	392	U56	BGA-225	SnPb	SAC	96		
100	393	U40	TSOP-50	SnPb	SAC	516		
100	394	U3	TQFP-208	AuPdNi	SAC			
100	395	U13	CLCC-20	SnPb	SAC	311		X
100	397	U57	TQFP-208	AuPdNi	SAC			
100	398	U14	CLCC-20	SAC	SAC	206		X
100	399	U15	PLCC-20	Sn	SAC			
100	400	U25	TSOP-50	SnCu	SAC	352		X
100	403	U58	TQFP-144	Sn	SAC	505		
100	404	U12	TSOP-50	SnCu	SAC	446		
100	406	U55	BGA-225	SAC	SAC	353		
100	407	U17	CLCC-20	SAC	SAC	226		X
100	408	U2	BGA-225	SnPb	SAC	270		
100	409	U31	TQFP-208	AuPdNi	SAC			
100	410	U45	CLCC-20	SAC	SAC	261		X
100	411	U46	CLCC-20	SnPb	SAC	352		X
100	412	U47	PLCC-20	Sn	SAC			
100	414	U24	TSOP-50	SnPb	SAC	334		X
100	416	U4	BGA-225	SAC	SAC	504		
100	417	U43	BGA-225	SAC	SAC	509		
100	418	U20	TQFP-144	Sn	SAC	353		
100	419	U21	BGA-225	SnPb	SAC	352		
100	420	U44	BGA-225	SnPb	SAC	354		
100	421	U61	TSOP-50	SnCu	SAC	351		X
100	422	U54	PLCC-20	Sn	SAC			
100	423	U48	TQFP-208	AuPdNi	SAC			
100	424	U7	TQFP-144	Sn	SAC	452		
100	425	U22	CLCC-20	SnPb	SAC	351		X
100	426	U16	TSOP-50	SnPb	SAC	351		
100	428	U11	PDIP-20	Sn	SAC			
100	429	U30	PDIP-20	Sn	SAC			
100	430	U35	PDIP-20	AuPdNi	SAC			
100	431	U38	PDIP-20	Sn	SAC			
100	432	U49	PDIP-20	AuPdNi	SAC			
100	433	U51	PDIP-20	Sn	SAC			
100	434	U59	PDIP-20	AuPdNi	SAC			
100	435	U63	PDIP-20	Sn	SAC			
100	436	U5	BGA-225	SnPb	SAC	30		
100	437	U6	BGA-225	SAC	SAC	112		
100	438	U34	TQFP-208	AuPdNi	SAC			
100	439	U52	CLCC-20	SAC	SAC	255		X
100	440	U53	CLCC-20	SnPb	SAC	351		X
100	441	U62	TSOP-50	SnPb	SAC	352		X
100	443	U10	CLCC-20	SAC	SAC	203		X
100	444	U28	PLCC-20	Sn	SAC			
100	445	U29	TSOP-50	SnCu	SAC	351		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
100	446	U8	PDIP-20	AuPdNi	SAC			
100	447	U23	PDIP-20	AuPdNi	SAC	0		
100	448	PTH's	PTH's		SAC			
31	449	U1	TQFP-144	Sn	SnPb			
31	450	U26	TSOP-50	SnPb	SnPb			
31	451	U41	TQFP-144	Sn	SnPb			
31	452	U9	CLCC-20	SnPb	SnPb	302		X
31	453	U27	PLCC-20	Sn	SnPb			
31	454	U18	BGA-225	SnPb	SnPb			
31	455	U39	TSOP-50	SnPb	SnPb			
31	456	U56	BGA-225	SnPb	SnPb			
31	457	U40	TSOP-50	SnPb	SnPb			
31	458	U3	TQFP-208	AuPdNi	SnPb			
31	459	U13	CLCC-20	SnPb	SnPb	295		X
31	461	U57	TQFP-208	AuPdNi	SnPb	507		
31	462	U14	CLCC-20	SnPb	SnPb	454		
31	463	U15	PLCC-20	Sn	SnPb			
31	464	U25	TSOP-50	SnPb	SnPb			
31	467	U58	TQFP-144	Sn	SnPb			
31	468	U12	TSOP-50	SnPb	SnPb			
31	470	U55	BGA-225	SnPb	SnPb			
31	471	U17	CLCC-20	SnPb	SnPb	351		
31	472	U2	BGA-225	SnPb	SnPb	469		
31	473	U31	TQFP-208	AuPdNi	SnPb			
31	474	U45	CLCC-20	SnPb	SnPb	464		
31	475	U46	CLCC-20	SnPb	SnPb	469		
31	476	U47	PLCC-20	Sn	SnPb			
31	478	U24	TSOP-50	SnPb	SnPb	549		
31	480	U4	BGA-225	SnPb	SnPb			
31	481	U43	BGA-225	SnPb	SnPb			
31	482	U20	TQFP-144	Sn	SnPb			
31	483	U21	BGA-225	SnPb	SnPb			
31	484	U44	BGA-225	SnPb	SnPb			
31	485	U61	TSOP-50	SnPb	SnPb			
31	486	U54	PLCC-20	Sn	SnPb			
31	487	U48	TQFP-208	AuPdNi	SnPb			
31	488	U7	TQFP-144	Sn	SnPb			
31	489	U22	CLCC-20	SnPb	SnPb	319		
31	490	U16	TSOP-50	SnPb	SnPb	513		
31	492	U11	PDIP-20	Sn	SnPb			
31	493	U30	PDIP-20	Sn	SnPb			
31	494	U35	PDIP-20	AuPdNi	SnPb			
31	495	U38	PDIP-20	Sn	SnPb			
31	496	U49	PDIP-20	AuPdNi	SnPb			
31	497	U51	PDIP-20	Sn	SnPb			
31	498	U59	PDIP-20	AuPdNi	SnPb			
31	499	U63	PDIP-20	Sn	SnPb			
31	500	U5	BGA-225	SnPb	SnPb			
31	501	U6	BGA-225	SnPb	SnPb			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
31	502	U34	TQFP-208	AuPdNi	SnPb			
31	503	U52	CLCC-20	SnPb	SnPb	355		X
31	504	U53	CLCC-20	SnPb	SnPb	396		X
31	505	U62	TSOP-50	SnPb	SnPb			
31	507	U10	CLCC-20	SnPb	SnPb	328		
31	508	U28	PLCC-20	Sn	SnPb			
31	509	U29	TSOP-50	SnPb	SnPb	510		
31	510	U8	PDIP-20	AuPdNi	SnPb			
31	511	U23	PDIP-20	AuPdNi	SnPb			
31	512	PTH's	PTH's		SnPb			
140	513	U1	TQFP-144	Sn	SACB			
140	514	U26	TSOP-50	SnPb	SACB	126		X
140	515	U41	TQFP-144	Sn	SACB			
140	516	U9	CLCC-20	SnPb	SACB	348		X
140	517	U27	PLCC-20	Sn	SACB			
140	518	U18	BGA-225	SAC	SACB	318		
140	519	U39	TSOP-50	SnCu	SACB			
140	520	U56	BGA-225	SnPb	SACB	522		
140	521	U40	TSOP-50	SnPb	SACB	262		X
140	522	U3	TQFP-208	AuPdNi	SACB			
140	523	U13	CLCC-20	SnPb	SACB	346		X
140	525	U57	TQFP-208	AuPdNi	SACB			
140	526	U14	CLCC-20	SACB	SACB			
140	527	U15	PLCC-20	Sn	SACB			
140	528	U25	TSOP-50	SnCu	SACB			
140	531	U58	TQFP-144	Sn	SACB			
140	532	U12	TSOP-50	SnCu	SACB	473		
140	534	U55	BGA-225	SAC	SACB			
140	535	U17	CLCC-20	SACB	SACB	399		
140	536	U2	BGA-225	SnPb	SACB	301		
140	537	U31	TQFP-208	AuPdNi	SACB			
140	538	U45	CLCC-20	SACB	SACB	500		
140	539	U46	CLCC-20	SnPb	SACB	448		X
140	540	U47	PLCC-20	Sn	SACB			
140	542	U24	TSOP-50	SnPb	SACB	268		X
140	544	U4	BGA-225	SAC	SACB	341		
140	545	U43	BGA-225	SAC	SACB	352		
140	546	U20	TQFP-144	Sn	SACB			
140	547	U21	BGA-225	SnPb	SACB	351		
140	548	U44	BGA-225	SnPb	SACB	440		
140	549	U61	TSOP-50	SnCu	SACB			
140	550	U54	PLCC-20	Sn	SACB			
140	551	U48	TQFP-208	AuPdNi	SACB			
140	552	U7	TQFP-144	Sn	SACB			
140	553	U22	CLCC-20	SnPb	SACB	352		X
140	554	U16	TSOP-50	SnPb	SACB	51		X
140	556	U11	PDIP-20	Sn	SnCu			
140	557	U30	PDIP-20	Sn	SnCu			
140	558	U35	PDIP-20	AuPdNi	SnCu			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
140	559	U38	PDIP-20	Sn	SnCu			
140	560	U49	PDIP-20	AuPdNi	SnCu			
140	561	U51	PDIP-20	Sn	SnCu			
140	562	U59	PDIP-20	AuPdNi	SnCu			
140	563	U63	PDIP-20	Sn	SnCu			
140	564	U5	BGA-225	SnPb	SACB	287		
140	565	U6	BGA-225	SAC	SACB	137		
140	566	U34	TQFP-208	AuPdNi	SACB			
140	567	U52	CLCC-20	SACB	SACB	441		
140	568	U53	CLCC-20	SnPb	SACB	476		
140	569	U62	TSOP-50	SnPb	SACB	285		X
140	571	U10	CLCC-20	SACB	SACB			
140	572	U28	PLCC-20	Sn	SACB			
140	573	U29	TSOP-50	SnCu	SACB	502		
140	574	U8	PDIP-20	AuPdNi	SnCu			
140	575	U23	PDIP-20	AuPdNi	SnCu			
140	576	PTH's	PTH's		SACB			
33	577	U1	TQFP-144	Sn	SnPb	327		
33	578	U26	TSOP-50	SnPb	SnPb	501		
33	579	U41	TQFP-144	Sn	SnPb			
33	580	U9	CLCC-20	SnPb	SnPb	305		X
33	581	U27	PLCC-20	Sn	SnPb			
33	582	U18	BGA-225	SnPb	SnPb	375		
33	583	U39	TSOP-50	SnPb	SnPb	462		
33	584	U56	BGA-225	SnPb	SnPb	384		
33	585	U40	TSOP-50	SnPb	SnPb	515		
33	586	U3	TQFP-208	AuPdNi	SnPb	520		
33	587	U13	CLCC-20	SnPb	SnPb	319		X
33	589	U57	TQFP-208	AuPdNi	SnPb	477		
33	590	U14	CLCC-20	SnPb	SnPb	352		X
33	591	U15	PLCC-20	Sn	SnPb			
33	592	U25	TSOP-50	SnPb	SnPb	411		
33	595	U58	TQFP-144	Sn	SnPb			
33	596	U12	TSOP-50	SnPb	SnPb	399		
33	598	U55	BGA-225	SnPb	SnPb	356		
33	599	U17	CLCC-20	SnPb	SnPb	324		X
33	600	U2	BGA-225	SnPb	SnPb	260		
33	601	U31	TQFP-208	AuPdNi	SnPb			
33	602	U45	CLCC-20	SnPb	SnPb	352		X
33	603	U46	CLCC-20	SnPb	SnPb	304		X
33	604	U47	PLCC-20	Sn	SnPb			
33	606	U24	TSOP-50	SnPb	SnPb	505		
33	608	U4	BGA-225	SnPb	SnPb	475		
33	609	U43	BGA-225	SnPb	SnPb	433		
33	610	U20	TQFP-144	Sn	SnPb			
33	611	U21	BGA-225	SnPb	SnPb	456		
33	612	U44	BGA-225	SnPb	SnPb	482		
33	613	U61	TSOP-50	SnPb	SnPb	498		
33	614	U54	PLCC-20	Sn	SnPb			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
33	615	U48	TQFP-208	AuPdNi	SnPb			
33	616	U7	TQFP-144	Sn	SnPb	504		
33	617	U22	CLCC-20	SnPb	SnPb	351		X
33	618	U16	TSOP-50	SnPb	SnPb	438		
33	620	U11	PDIP-20	Sn	SnPb			
33	621	U30	PDIP-20	Sn	SnPb			
33	622	U35	PDIP-20	AuPdNi	SnPb			
33	623	U38	PDIP-20	Sn	SnPb			
33	624	U49	PDIP-20	AuPdNi	SnPb			
33	625	U51	PDIP-20	Sn	SnPb			
33	626	U59	PDIP-20	AuPdNi	SnPb			
33	627	U63	PDIP-20	Sn	SnPb			
33	628	U5	BGA-225	SnPb	SnPb	510		
33	629	U6	BGA-225	SnPb	SnPb	366		
33	630	U34	TQFP-208	AuPdNi	SnPb			
33	631	U52	CLCC-20	SnPb	SnPb	353		X
33	632	U53	CLCC-20	SnPb	SnPb	330		X
33	633	U62	TSOP-50	SnPb	SnPb	504		
33	635	U10	CLCC-20	SnPb	SnPb	352		X
33	636	U28	PLCC-20	Sn	SnPb			
33	637	U29	TSOP-50	SnPb	SnPb	351		
33	638	U8	PDIP-20	AuPdNi	SnPb			
33	639	U23	PDIP-20	AuPdNi	SnPb			
33	640	PTH's	PTH's		SnPb			
99	641	U1	TQFP-144	Sn	SAC	522		
99	642	U26	TSOP-50	SnPb	SAC	356		
99	643	U41	TQFP-144	Sn	SAC			
99	644	U9	CLCC-20	SnPb	SAC	309		X
99	645	U27	PLCC-20	Sn	SAC			
99	646	U18	BGA-225	SAC	SAC	353		
99	647	U39	TSOP-50	SnCu	SAC	473		
99	648	U56	BGA-225	SnPb	SAC	352		
99	649	U40	TSOP-50	SnPb	SAC	460		
99	650	U3	TQFP-208	AuPdNi	SAC			
99	651	U13	CLCC-20	SnPb	SAC	297		X
99	653	U57	TQFP-208	AuPdNi	SAC			
99	654	U14	CLCC-20	SAC	SAC	275		X
99	655	U15	PLCC-20	Sn	SAC			
99	656	U25	TSOP-50	SnCu	SAC	298		
99	659	U58	TQFP-144	Sn	SAC			
99	660	U12	TSOP-50	SnCu	SAC	315		
99	662	U55	BGA-225	SAC	SAC	413		
99	663	U17	CLCC-20	SAC	SAC	277		X
99	664	U2	BGA-225	SnPb	SAC	297		
99	665	U31	TQFP-208	AuPdNi	SAC			
99	666	U45	CLCC-20	SAC	SAC	260		X
99	667	U46	CLCC-20	SnPb	SAC	353		
99	668	U47	PLCC-20	Sn	SAC			
99	670	U24	TSOP-50	SnPb	SAC	350		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
99	672	U4	BGA-225	SAC	SAC	327		
99	673	U43	BGA-225	SAC	SAC	334		
99	674	U20	TQFP-144	Sn	SAC			
99	675	U21	BGA-225	SnPb	SAC	323		
99	676	U44	BGA-225	SnPb	SAC	349		
99	677	U61	TSOP-50	SnCu	SAC	352		
99	678	U54	PLCC-20	Sn	SAC			
99	679	U48	TQFP-208	AuPdNi	SAC			
99	680	U7	TQFP-144	Sn	SAC	373		
99	681	U22	CLCC-20	SnPb	SAC	286		X
99	682	U16	TSOP-50	SnPb	SAC	323		
99	684	U11	PDIP-20	Sn	SAC			
99	685	U30	PDIP-20	Sn	SAC			
99	686	U35	PDIP-20	AuPdNi	SAC			
99	687	U38	PDIP-20	Sn	SAC			
99	688	U49	PDIP-20	AuPdNi	SAC			
99	689	U51	PDIP-20	Sn	SAC			
99	690	U59	PDIP-20	AuPdNi	SAC			
99	691	U63	PDIP-20	Sn	SAC			
99	692	U5	BGA-225	SnPb	SAC	336		
99	693	U6	BGA-225	SAC	SAC	353		
99	694	U34	TQFP-208	AuPdNi	SAC			
99	695	U52	CLCC-20	SAC	SAC	271		X
99	696	U53	CLCC-20	SnPb	SAC	325		X
99	697	U62	TSOP-50	SnPb	SAC	372		
99	699	U10	CLCC-20	SAC	SAC	254		X
99	700	U28	PLCC-20	Sn	SAC			
99	701	U29	TSOP-50	SnCu	SAC	304		X
99	702	U8	PDIP-20	AuPdNi	SAC			
99	703	U23	PDIP-20	AuPdNi	SAC			
99	704	PTH's	PTH's		SAC			
30	705	U1	TQFP-144	Sn	SnPb	549		
30	706	U26	TSOP-50	SnPb	SnPb			
30	707	U41	TQFP-144	Sn	SnPb			
30	708	U9	CLCC-20	SnPb	SnPb	351		X
30	709	U27	PLCC-20	Sn	SnPb			
30	710	U18	BGA-225	SnPb	SnPb	505		
30	711	U39	TSOP-50	SnPb	SnPb			
30	712	U56	BGA-225	SnPb	SnPb			
30	713	U40	TSOP-50	SnPb	SnPb			
30	714	U3	TQFP-208	AuPdNi	SnPb			
30	715	U13	CLCC-20	SnPb	SnPb	314		X
30	717	U57	TQFP-208	AuPdNi	SnPb	51		
30	718	U14	CLCC-20	SnPb	SnPb	351		X
30	719	U15	PLCC-20	Sn	SnPb			
30	720	U25	TSOP-50	SnPb	SnPb			
30	723	U58	TQFP-144	Sn	SnPb			
30	724	U12	TSOP-50	SnPb	SnPb	546		
30	726	U55	BGA-225	SnPb	SnPb	541		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
30	727	U17	CLCC-20	SnPb	SnPb	401		
30	728	U2	BGA-225	SnPb	SnPb	405		
30	729	U31	TQFP-208	AuPdNi	SnPb			
30	730	U45	CLCC-20	SnPb	SnPb	422		
30	731	U46	CLCC-20	SnPb	SnPb	421		
30	732	U47	PLCC-20	Sn	SnPb			
30	734	U24	TSOP-50	SnPb	SnPb	510		
30	736	U4	BGA-225	SnPb	SnPb	418		
30	737	U43	BGA-225	SnPb	SnPb			
30	738	U20	TQFP-144	Sn	SnPb			
30	739	U21	BGA-225	SnPb	SnPb	504		
30	740	U44	BGA-225	SnPb	SnPb			
30	741	U61	TSOP-50	SnPb	SnPb			
30	742	U54	PLCC-20	Sn	SnPb			
30	743	U48	TQFP-208	AuPdNi	SnPb			
30	744	U7	TQFP-144	Sn	SnPb			
30	745	U22	CLCC-20	SnPb	SnPb	361		
30	746	U16	TSOP-50	SnPb	SnPb	444		
30	748	U11	PDIP-20	Sn	SnPb			
30	749	U30	PDIP-20	Sn	SnPb			
30	750	U35	PDIP-20	AuPdNi	SnPb			
30	751	U38	PDIP-20	Sn	SnPb			
30	752	U49	PDIP-20	AuPdNi	SnPb			
30	753	U51	PDIP-20	Sn	SnPb			
30	754	U59	PDIP-20	AuPdNi	SnPb			
30	755	U63	PDIP-20	Sn	SnPb			
30	756	U5	BGA-225	SnPb	SnPb	352		
30	757	U6	BGA-225	SnPb	SnPb	465		
30	758	U34	TQFP-208	AuPdNi	SnPb			
30	759	U52	CLCC-20	SnPb	SnPb	357		
30	760	U53	CLCC-20	SnPb	SnPb	352		
30	761	U62	TSOP-50	SnPb	SnPb	504		
30	763	U10	CLCC-20	SnPb	SnPb	279		X
30	764	U28	PLCC-20	Sn	SnPb			
30	765	U29	TSOP-50	SnPb	SnPb	512		
30	766	U8	PDIP-20	AuPdNi	SnPb			
30	767	U23	PDIP-20	AuPdNi	SnPb			
30	768	PTH's	PTH's		SnPb			
101	769	U1	TQFP-144	Sn	SAC	533		
101	770	U26	TSOP-50	SnPb	SAC	397		
101	771	U41	TQFP-144	Sn	SAC			
101	772	U9	CLCC-20	SnPb	SAC	332		X
101	773	U27	PLCC-20	Sn	SAC			
101	774	U18	BGA-225	SAC	SAC	351		
101	775	U39	TSOP-50	SnCu	SAC	403		X
101	776	U56	BGA-225	SnPb	SAC	317		
101	777	U40	TSOP-50	SnPb	SAC	404		
101	778	U3	TQFP-208	AuPdNi	SAC	455		
101	779	U13	CLCC-20	SnPb	SAC	309		X

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
101	781	U57	TQFP-208	AuPdNi	SAC			
101	782	U14	CLCC-20	SAC	SAC	256		X
101	783	U15	PLCC-20	Sn	SAC			
101	784	U25	TSOP-50	SnCu	SAC	291		X
101	787	U58	TQFP-144	Sn	SAC	550		
101	788	U12	TSOP-50	SnCu	SAC	353		
101	790	U55	BGA-225	SAC	SAC	514		
101	791	U17	CLCC-20	SAC	SAC	303		X
101	792	U2	BGA-225	SnPb	SAC	258		
101	793	U31	TQFP-208	AuPdNi	SAC			
101	794	U45	CLCC-20	SAC	SAC	301		X
101	795	U46	CLCC-20	SnPb	SAC	315		X
101	796	U47	PLCC-20	Sn	SAC			
101	798	U24	TSOP-50	SnPb	SAC	498		
101	800	U4	BGA-225	SAC	SAC	317		
101	801	U43	BGA-225	SAC	SAC	418		
101	802	U20	TQFP-144	Sn	SAC			
101	803	U21	BGA-225	SnPb	SAC	418		
101	804	U44	BGA-225	SnPb	SAC			
101	805	U61	TSOP-50	SnCu	SAC	403		
101	806	U54	PLCC-20	Sn	SAC			
101	807	U48	TQFP-208	AuPdNi	SAC			
101	808	U7	TQFP-144	Sn	SAC			
101	809	U22	CLCC-20	SnPb	SAC	280		X
101	810	U16	TSOP-50	SnPb	SAC	372		
101	812	U11	PDIP-20	Sn	SAC			
101	813	U30	PDIP-20	Sn	SAC			
101	814	U35	PDIP-20	AuPdNi	SAC			
101	815	U38	PDIP-20	Sn	SAC			
101	816	U49	PDIP-20	AuPdNi	SAC			
101	817	U51	PDIP-20	Sn	SAC			
101	818	U59	PDIP-20	AuPdNi	SAC			
101	819	U63	PDIP-20	Sn	SAC			
101	820	U5	BGA-225	SnPb	SAC	264		
101	821	U6	BGA-225	SAC	SAC	388		
101	822	U34	TQFP-208	AuPdNi	SAC			
101	823	U52	CLCC-20	SAC	SAC	280		X
101	824	U53	CLCC-20	SnPb	SAC	312		X
101	825	U62	TSOP-50	SnPb	SAC	520		
101	827	U10	CLCC-20	SAC	SAC	256		X
101	828	U28	PLCC-20	Sn	SAC			
101	829	U29	TSOP-50	SnCu	SAC	347		
101	830	U8	PDIP-20	AuPdNi	SAC	0		
101	831	U23	PDIP-20	AuPdNi	SAC			
101	832	PTH's	PTH's		SAC			
102	833	U1	TQFP-144	Sn	SAC	324		
102	834	U26	TSOP-50	SnPb	SAC	351		
102	835	U41	TQFP-144	Sn	SAC			
102	836	U9	CLCC-20	SnPb	SAC	230		X

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
102	837	U27	PLCC-20	Sn	SAC			
102	838	U18	BGA-225	SAC	SAC	346		
102	839	U39	TSOP-50	SnCu	SAC	442		
102	840	U56	BGA-225	SnPb	SAC	38		
102	841	U40	TSOP-50	SnPb	SAC	512		
102	842	U3	TQFP-208	AuPdNi	SAC			
102	843	U13	CLCC-20	SnPb	SAC	271		X
102	845	U57	TQFP-208	AuPdNi	SAC			
102	846	U14	CLCC-20	SAC	SAC	168		X
102	847	U15	PLCC-20	Sn	SAC			
102	848	U25	TSOP-50	SnCu	SAC	293		X
102	851	U58	TQFP-144	Sn	SAC			
102	852	U12	TSOP-50	SnCu	SAC	221		
102	854	U55	BGA-225	SAC	SAC	222		
102	855	U17	CLCC-20	SAC	SAC	171		X
102	856	U2	BGA-225	SnPb	SAC	126		
102	857	U31	TQFP-208	AuPdNi	SAC	526		
102	858	U45	CLCC-20	SAC	SAC	206		X
102	859	U46	CLCC-20	SnPb	SAC	284		X
102	860	U47	PLCC-20	Sn	SAC			
102	862	U24	TSOP-50	SnPb	SAC	301		X
102	864	U4	BGA-225	SAC	SAC	112		
102	865	U43	BGA-225	SAC	SAC	503		
102	866	U20	TQFP-144	Sn	SAC	506		
102	867	U21	BGA-225	SnPb	SAC	50		
102	868	U44	BGA-225	SnPb	SAC	540		
102	869	U61	TSOP-50	SnCu	SAC	352		
102	870	U54	PLCC-20	Sn	SAC			
102	871	U48	TQFP-208	AuPdNi	SAC			
102	872	U7	TQFP-144	Sn	SAC	308		
102	873	U22	CLCC-20	SnPb	SAC	275		X
102	874	U16	TSOP-50	SnPb	SAC	352		
102	876	U11	PDIP-20	Sn	SAC			
102	877	U30	PDIP-20	Sn	SAC			
102	878	U35	PDIP-20	AuPdNi	SAC			
102	879	U38	PDIP-20	Sn	SAC			
102	880	U49	PDIP-20	AuPdNi	SAC			
102	881	U51	PDIP-20	Sn	SAC			
102	882	U59	PDIP-20	AuPdNi	SAC			
102	883	U63	PDIP-20	Sn	SAC			
102	884	U5	BGA-225	SnPb	SAC	52		
102	885	U6	BGA-225	SAC	SAC	100		
102	886	U34	TQFP-208	AuPdNi	SAC			
102	887	U52	CLCC-20	SAC	SAC	203		X
102	888	U53	CLCC-20	SnPb	SAC	299		X
102	889	U62	TSOP-50	SnPb	SAC	504		
102	891	U10	CLCC-20	SAC	SAC	191		X
102	892	U28	PLCC-20	Sn	SAC			
102	893	U29	TSOP-50	SnCu	SAC	299		X

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
102	894	U8	PDIP-20	AuPdNi	SAC			
102	895	U23	PDIP-20	AuPdNi	SAC			
102	896	PTH's	PTH's		SAC			
113	897	U1	TQFP-144	Sn	SACB			
113	898	U26	TSOP-50	SnPb	SACB	103		X
113	899	U41	TQFP-144	Sn	SACB			
113	900	U9	CLCC-20	SnPb	SACB	351		
113	901	U27	PLCC-20	Sn	SACB			
113	902	U18	BGA-225	SAC	SACB			
113	903	U39	TSOP-50	SnCu	SACB			
113	904	U56	BGA-225	SnPb	SACB			
113	905	U40	TSOP-50	SnPb	SACB	204		
113	906	U3	TQFP-208	AuPdNi	SACB			
113	907	U13	CLCC-20	SnPb	SACB	368		
113	909	U57	TQFP-208	AuPdNi	SACB			
113	910	U14	CLCC-20	SACB	SACB	512		
113	911	U15	PLCC-20	Sn	SACB			
113	912	U25	TSOP-50	SnCu	SACB			
113	915	U58	TQFP-144	Sn	SACB			
113	916	U12	TSOP-50	SnCu	SACB			
113	918	U55	BGA-225	SAC	SACB			
113	919	U17	CLCC-20	SACB	SACB	507		
113	920	U2	BGA-225	SnPb	SACB	298		
113	921	U31	TQFP-208	AuPdNi	SACB			
113	922	U45	CLCC-20	SACB	SACB	509		
113	923	U46	CLCC-20	SnPb	SACB	499		
113	924	U47	PLCC-20	Sn	SACB			
113	926	U24	TSOP-50	SnPb	SACB	205		X
113	928	U4	BGA-225	SAC	SACB	550		
113	929	U43	BGA-225	SAC	SACB			
113	930	U20	TQFP-144	Sn	SACB			
113	931	U21	BGA-225	SnPb	SACB			
113	932	U44	BGA-225	SnPb	SACB			
113	933	U61	TSOP-50	SnCu	SACB			
113	934	U54	PLCC-20	Sn	SACB			
113	935	U48	TQFP-208	AuPdNi	SACB			
113	936	U7	TQFP-144	Sn	SACB			
113	937	U22	CLCC-20	SnPb	SACB	407		X
113	938	U16	TSOP-50	SnPb	SACB	71		X
113	940	U11	PDIP-20	Sn	SnCu			
113	941	U30	PDIP-20	Sn	SnCu			
113	942	U35	PDIP-20	AuPdNi	SnCu			
113	943	U38	PDIP-20	Sn	SnCu			
113	944	U49	PDIP-20	AuPdNi	SnCu			
113	945	U51	PDIP-20	Sn	SnCu			
113	946	U59	PDIP-20	AuPdNi	SnCu			
113	947	U63	PDIP-20	Sn	SnCu			
113	948	U5	BGA-225	SnPb	SACB			
113	949	U6	BGA-225	SAC	SACB	413		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at First Failure	Comments	Missing After CET
113	950	U34	TQFP-208	AuPdNi	SACB			
113	951	U52	CLCC-20	SACB	SACB	363		
113	952	U53	CLCC-20	SnPb	SACB	407		
113	953	U62	TSOP-50	SnPb	SACB	261		X
113	955	U10	CLCC-20	SACB	SACB	510		
113	956	U28	PLCC-20	Sn	SACB			
113	957	U29	TSOP-50	SnCu	SACB			
113	958	U8	PDIP-20	AuPdNi	SnCu			
113	959	U23	PDIP-20	AuPdNi	SnCu			
113	960	PTH's	PTH's		SACB			

Appendix B: Rework Assembly Raw Test Data

Table 22 Rework Assembly Raw Data

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
175	1	U1	TQFP-144	Sn			287		X
175	2	U26	TSOP-50	SnCu			349		X
175	3	U41	TQFP-144	Sn			452		X
175	4	U9	CLCC-20	SAC			236		X
175	5	U27	PLCC-20	Sn					X
175	6	U18	BGA-225	SnPb	SAC		406		
175	7	U39	TSOP-50	SnCu			393		X
175	8	U56	BGA-225	SAC			217		X
175	9	U40	TSOP-50	SnCu			400		X
175	10	U3	TQFP-208	AuPdNi	AuPdNi	SAC	96		
175	11	U13	CLCC-20	SAC			206		X
175	13	U57	TQFP-208	AuPdNi	AuPdNi	SAC			
175	14	U14	CLCC-20	SAC			255		X
175	15	U15	PLCC-20	Sn					X
175	16	U25	TSOP-50	SnPb	SnCu	SAC	346		
175	19	U58	TQFP-144	Sn					X
175	20	U12	TSOP-50	SnPb	SnCu	SAC	156		
175	22	U55	BGA-225	SAC			255		X
175	23	U17	CLCC-20	SAC			276		X
175	24	U2	BGA-225	SAC			190		
175	25	U31	TQFP-208	AuPdNi			531		X
175	26	U45	CLCC-20	SAC			301		X
175	27	U46	CLCC-20	SAC			287		X
175	28	U47	PLCC-20	Sn					X
175	30	U24	TSOP-50	SnCu			378		X
175	32	U4	BGA-225	SnPb	SAC				
175	33	U43	BGA-225	SAC			267		X
175	34	U20	TQFP-144	Sn					
175	35	U21	BGA-225	SAC			160		
175	36	U44	BGA-225	SAC			255		X
175	37	U61	TSOP-50	SnCu			457		X
175	38	U54	PLCC-20	Sn					X
175	39	U48	TQFP-208	AuPdNi					X
175	40	U7	TQFP-144	Sn			381		
175	41	U22	CLCC-20	SAC			263		X
175	42	U16	TSOP-50	SnCu			408		X
175	44	U11	PDIP-20	Sn					
175	45	U30	PDIP-20	Sn					
175	46	U35	PDIP-20	AuPdNi					
175	47	U38	PDIP-20	Sn					
175	48	U49	PDIP-20	AuPdNi					
175	49	U51	PDIP-20	Sn					
175	50	U59	PDIP-20	AuPdNi	AuPdNi	SAC	508		
175	51	U63	PDIP-20	Sn					
175	52	U5	BGA-225	SAC			107		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
175	53	U6	BGA-225	SAC			148		
175	54	U34	TQFP-208	AuPdNi					X
175	55	U52	CLCC-20	SAC			225		X
175	56	U53	CLCC-20	SAC			245		X
175	57	U62	TSOP-50	SnCu			420		X
175	59	U10	CLCC-20	SAC			236		X
175	60	U28	PLCC-20	Sn					X
175	61	U29	TSOP-50	SnCu			388		X
175	62	U8	PDIP-20	AuPdNi					
175	63	U23	PDIP-20	AuPdNi	AuPdNi	SAC			
175	64	PTH's	PTH						
202	65	U1	TQFP-144	Sn			508		
202	66	U26	TSOP-50	SnCu			455		X
202	67	U41	TQFP-144	Sn					X
202	68	U9	CLCC-20	SACB			306		X
202	69	U27	PLCC-20	Sn					
202	70	U18	BGA-225	SnPb	SAC		502		
202	71	U39	TSOP-50	SnCu			522		
202	72	U56	BGA-225	SAC			349		
202	73	U40	TSOP-50	SnCu			512		
202	74	U3	TQFP-208	AuPdNi	AuPdNi	SACB	14		X
202	75	U13	CLCC-20	SACB			299		X
202	77	U57	TQFP-208	AuPdNi	AuPdNi	SACB	394		X
202	78	U14	CLCC-20	SACB			252		X
202	79	U15	PLCC-20	Sn					
202	80	U25	TSOP-50	SnPb	SnCu	SACB	228		X
202	83	U58	TQFP-144	Sn			508		
202	84	U12	TSOP-50	SnPb	SnCu	SACB	219		X
202	86	U55	BGA-225	SAC			433		
202	87	U17	CLCC-20	SACB			322		X
202	88	U2	BGA-225	SAC			5		
202	89	U31	TQFP-208	AuPdNi			528		X
202	90	U45	CLCC-20	SACB			353		X
202	91	U46	CLCC-20	SACB			301		X
202	92	U47	PLCC-20	Sn					
202	94	U24	TSOP-50	SnCu			405		X
202	96	U4	BGA-225	SnPb	SAC		511		
202	97	U43	BGA-225	SAC			312		
202	98	U20	TQFP-144	Sn			531		
202	99	U21	BGA-225	SAC			196		
202	100	U44	BGA-225	SAC			397		
202	101	U61	TSOP-50	SnCu			462		
202	102	U54	PLCC-20	Sn					
202	103	U48	TQFP-208	AuPdNi					
202	104	U7	TQFP-144	Sn			503		
202	105	U22	CLCC-20	SACB			278		X
202	106	U16	TSOP-50	SnCu			405		
202	108	U11	PDIP-20	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
202	109	U30	PDIP-20	Sn					
202	110	U35	PDIP-20	AuPdNi					
202	111	U38	PDIP-20	Sn					
202	112	U49	PDIP-20	AuPdNi					
202	113	U51	PDIP-20	Sn					
202	114	U59	PDIP-20	AuPdNi	AuPdNi	SnCu			
202	115	U63	PDIP-20	Sn					
202	116	U5	BGA-225	SAC			88		
202	117	U6	BGA-225	SAC			135		
202	118	U34	TQFP-208	AuPdNi					
202	119	U52	CLCC-20	SACB			338		X
202	120	U53	CLCC-20	SACB			407		X
202	121	U62	TSOP-50	SnCu			423		
202	123	U10	CLCC-20	SACB			254		X
202	124	U28	PLCC-20	Sn					
202	125	U29	TSOP-50	SnCu			441		
202	126	U8	PDIP-20	AuPdNi					
202	127	U23	PDIP-20	AuPdNi	AuPdNi	SnCu			
202	128	PTH's	PTH						
70	129	U1	TQFP-144	Sn			436		X
70	130	U26	TSOP-50	SnPb			318		X
70	131	U41	TQFP-144	Sn			375		X
70	132	U9	CLCC-20	SnPb			311		X
70	133	U27	PLCC-20	Sn					
70	134	U18	BGA-225	SnPb	SnPb		303		
70	135	U39	TSOP-50	SnPb			310		X
70	136	U56	BGA-225	SnPb			305		
70	137	U40	TSOP-50	SnPb			314		X
70	138	U3	TQFP-208	AuPdNi	AuPdNi	SnPb	148		X
70	139	U13	CLCC-20	SnPb			302		X
70	141	U57	TQFP-208	AuPdNi	AuPdNi	SnPb	307		X
70	142	U14	CLCC-20	SnPb			301		X
70	143	U15	PLCC-20	Sn					
70	144	U25	TSOP-50	SnPb	SnPb	SnPb	300		X
70	147	U58	TQFP-144	Sn			261		X
70	148	U12	TSOP-50	SnPb	SnPb	SnPb	306		X
70	150	U55	BGA-225	SnPb			304		
70	151	U17	CLCC-20	SnPb			309		X
70	152	U2	BGA-225	SnPb			219		
70	153	U31	TQFP-208	AuPdNi			354		X
70	154	U45	CLCC-20	SnPb			307		X
70	155	U46	CLCC-20	SnPb			326		X
70	156	U47	PLCC-20	Sn					
70	158	U24	TSOP-50	SnPb			288		X
70	160	U4	BGA-225	SnPb	SnPb		252		
70	161	U43	BGA-225	SnPb			267		
70	162	U20	TQFP-144	Sn			324		X
70	163	U21	BGA-225	SnPb			290		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
70	164	U44	BGA-225	SnPb			298		
70	165	U61	TSOP-50	SnPb			286		X
70	166	U54	PLCC-20	Sn					
70	167	U48	TQFP-208	AuPdNi			324		X
70	168	U7	TQFP-144	Sn			307		X
70	169	U22	CLCC-20	SnPb			314		X
70	170	U16	TSOP-50	SnPb			254		X
70	172	U11	PDIP-20	Sn					
70	173	U30	PDIP-20	Sn					
70	174	U35	PDIP-20	AuPdNi					
70	175	U38	PDIP-20	Sn					
70	176	U49	PDIP-20	AuPdNi					
70	177	U51	PDIP-20	Sn					
70	178	U59	PDIP-20	AuPdNi	AuPdNi	SnPb			
70	179	U63	PDIP-20	Sn					
70	180	U5	BGA-225	SnPb			238		
70	181	U6	BGA-225	SnPb			322		
70	182	U34	TQFP-208	AuPdNi			325		X
70	183	U52	CLCC-20	SnPb			301		X
70	184	U53	CLCC-20	SnPb			303		X
70	185	U62	TSOP-50	SnPb			254		X
70	187	U10	CLCC-20	SnPb			301		X
70	188	U28	PLCC-20	Sn					
70	189	U29	TSOP-50	SnPb			286		X
70	190	U8	PDIP-20	AuPdNi					
70	191	U23	PDIP-20	AuPdNi	AuPdNi	SnPb	528		
70	192	PTH's	PTH						
172	193	U1	TQFP-144	Sn			359		
172	194	U26	TSOP-50	SnCu			325		X
172	195	U41	TQFP-144	Sn			442		X
172	196	U9	CLCC-20	SAC			201		X
172	197	U27	PLCC-20	Sn					X
172	198	U18	BGA-225	SnPb	SAC		504		
172	199	U39	TSOP-50	SnCu			415		X
172	200	U56	BGA-225	SAC			285		X
172	201	U40	TSOP-50	SnCu			431		X
172	202	U3	TQFP-208	AuPdNi	AuPdNi	SAC	52		
172	203	U13	CLCC-20	SAC			250		X
172	205	U57	TQFP-208	AuPdNi	AuPdNi	SAC			
172	206	U14	CLCC-20	SAC			263		X
172	207	U15	PLCC-20	Sn					X
172	208	U25	TSOP-50	SnPb	SnCu	SAC	470		
172	211	U58	TQFP-144	Sn					
172	212	U12	TSOP-50	SnPb	SnCu	SAC	202		X
172	214	U55	BGA-225	SAC			304		X
172	215	U17	CLCC-20	SAC			291		X
172	216	U2	BGA-225	SAC			151		
172	217	U31	TQFP-208	AuPdNi			421		X

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
172	218	U45	CLCC-20	SAC			201		X
172	219	U46	CLCC-20	SAC			203		X
172	220	U47	PLCC-20	Sn					X
172	222	U24	TSOP-50	SnCu			370		X
172	224	U4	BGA-225	SnPb	SAC		382		
172	225	U43	BGA-225	SAC			264		X
172	226	U20	TQFP-144	Sn					X
172	227	U21	BGA-225	SAC			97		X
172	228	U44	BGA-225	SAC			168		X
172	229	U61	TSOP-50	SnCu			457		X
172	230	U54	PLCC-20	Sn					X
172	231	U48	TQFP-208	AuPdNi					X
172	232	U7	TQFP-144	Sn			425		
172	233	U22	CLCC-20	SAC			242		X
172	234	U16	TSOP-50	SnCu			323		X
172	236	U11	PDIP-20	Sn					
172	237	U30	PDIP-20	Sn					
172	238	U35	PDIP-20	AuPdNi					
172	239	U38	PDIP-20	Sn					
172	240	U49	PDIP-20	AuPdNi					
172	241	U51	PDIP-20	Sn					
172	242	U59	PDIP-20	AuPdNi	AuPdNi	SAC	531		
172	243	U63	PDIP-20	Sn					
172	244	U5	BGA-225	SAC			107		
172	245	U6	BGA-225	SAC			126		
172	246	U34	TQFP-208	AuPdNi					X
172	247	U52	CLCC-20	SAC			218		X
172	248	U53	CLCC-20	SAC			258		X
172	249	U62	TSOP-50	SnCu			432		
172	251	U10	CLCC-20	SAC			202		X
172	252	U28	PLCC-20	Sn					X
172	253	U29	TSOP-50	SnCu			417		X
172	254	U8	PDIP-20	AuPdNi					
172	255	U23	PDIP-20	AuPdNi	AuPdNi	SAC			
172	256	PTH's	PTH						
67	257	U1	TQFP-144	Sn			356		
67	258	U26	TSOP-50	SnPb			337		X
67	259	U41	TQFP-144	Sn					X
67	260	U9	CLCC-20	SnPb			309		X
67	261	U27	PLCC-20	Sn					X
67	262	U18	BGA-225	SnPb	SnPb		325		
67	263	U39	TSOP-50	SnPb			370		
67	264	U56	BGA-225	SnPb			340		
67	265	U40	TSOP-50	SnPb			420		
67	266	U3	TQFP-208	AuPdNi	AuPdNi	SnPb	155		X
67	267	U13	CLCC-20	SnPb			302		X
67	269	U57	TQFP-208	AuPdNi	AuPdNi	SnPb	367		X
67	270	U14	CLCC-20	SnPb			300		X

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
67	271	U15	PLCC-20	Sn					
67	272	U25	TSOP-50	SnPb	SnPb	SnPb	249		X
67	275	U58	TQFP-144	Sn			471		
67	276	U12	TSOP-50	SnPb	SnPb	SnPb	311		X
67	278	U55	BGA-225	SnPb			310		
67	279	U17	CLCC-20	SnPb			334		X
67	280	U2	BGA-225	SnPb			193		
67	281	U31	TQFP-208	AuPdNi					
67	282	U45	CLCC-20	SnPb			363		X
67	283	U46	CLCC-20	SnPb			394		
67	284	U47	PLCC-20	Sn					X
67	286	U24	TSOP-50	SnPb			337		X
67	288	U4	BGA-225	SnPb	SnPb		287		
67	289	U43	BGA-225	SnPb			315		
67	290	U20	TQFP-144	Sn			496		
67	291	U21	BGA-225	SnPb			339		
67	292	U44	BGA-225	SnPb			402		
67	293	U61	TSOP-50	SnPb			337		
67	294	U54	PLCC-20	Sn					
67	295	U48	TQFP-208	AuPdNi					
67	296	U7	TQFP-144	Sn			333		
67	297	U22	CLCC-20	SnPb			354		X
67	298	U16	TSOP-50	SnPb			388		
67	300	U11	PDIP-20	Sn					
67	301	U30	PDIP-20	Sn					
67	302	U35	PDIP-20	AuPdNi					
67	303	U38	PDIP-20	Sn					
67	304	U49	PDIP-20	AuPdNi					
67	305	U51	PDIP-20	Sn					
67	306	U59	PDIP-20	AuPdNi	AuPdNi	SnPb			
67	307	U63	PDIP-20	Sn					
67	308	U5	BGA-225	SnPb			261		
67	309	U6	BGA-225	SnPb			311		
67	310	U34	TQFP-208	AuPdNi					
67	311	U52	CLCC-20	SnPb			392		X
67	312	U53	CLCC-20	SnPb			403		
67	313	U62	TSOP-50	SnPb			340		
67	315	U10	CLCC-20	SnPb			369		
67	316	U28	PLCC-20	Sn					
67	317	U29	TSOP-50	SnPb			418		
67	318	U8	PDIP-20	AuPdNi					
67	319	U23	PDIP-20	AuPdNi	AuPdNi	SnPb			
67	320	PTH's	PTH						
173	321	U1	TQFP-144	Sn			530		
173	322	U26	TSOP-50	SnCu			391		
173	323	U41	TQFP-144	Sn			504		
173	324	U9	CLCC-20	SAC			224		X
173	325	U27	PLCC-20	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
173	326	U18	BGA-225	SnPb	SAC		486		
173	327	U39	TSOP-50	SnCu			341		X
173	328	U56	BGA-225	SAC			306		
173	329	U40	TSOP-50	SnCu			410		
173	330	U3	TQFP-208	AuPdNi	AuPdNi	SAC	137		
173	331	U13	CLCC-20	SAC			188		X
173	333	U57	TQFP-208	AuPdNi	AuPdNi	SAC	256		
173	334	U14	CLCC-20	SAC			262		X
173	335	U15	PLCC-20	Sn					
173	336	U25	TSOP-50	SnPb	SnCu	SAC	311		
173	339	U58	TQFP-144	Sn					
173	340	U12	TSOP-50	SnPb	SnCu	SAC	305		
173	342	U55	BGA-225	SAC			314		
173	343	U17	CLCC-20	SAC			299		X
173	344	U2	BGA-225	SAC			240		
173	345	U31	TQFP-208	AuPdNi			510		
173	346	U45	CLCC-20	SAC			258		X
173	347	U46	CLCC-20	SAC			227		X
173	348	U47	PLCC-20	Sn					
173	350	U24	TSOP-50	SnCu			320		
173	352	U4	BGA-225	SnPb	SAC		315		
173	353	U43	BGA-225	SAC			202		
173	354	U20	TQFP-144	Sn			508		
173	355	U21	BGA-225	SAC			167		
173	356	U44	BGA-225	SAC			263		
173	357	U61	TSOP-50	SnCu			352		X
173	358	U54	PLCC-20	Sn			509		
173	359	U48	TQFP-208	AuPdNi			386		X
173	360	U7	TQFP-144	Sn			316		X
173	361	U22	CLCC-20	SAC			227		X
173	362	U16	TSOP-50	SnCu			303		X
173	364	U11	PDIP-20	Sn					
173	365	U30	PDIP-20	Sn					
173	366	U35	PDIP-20	AuPdNi					
173	367	U38	PDIP-20	Sn					
173	368	U49	PDIP-20	AuPdNi					
173	369	U51	PDIP-20	Sn					
173	370	U59	PDIP-20	AuPdNi	AuPdNi	SAC	360		
173	371	U63	PDIP-20	Sn					
173	372	U5	BGA-225	SAC			202		
173	373	U6	BGA-225	SAC			216		
173	374	U34	TQFP-208	AuPdNi			508		X
173	375	U52	CLCC-20	SAC			269		X
173	376	U53	CLCC-20	SAC			301		X
173	377	U62	TSOP-50	SnCu			348		
173	379	U10	CLCC-20	SAC			186		X
173	380	U28	PLCC-20	Sn					
173	381	U29	TSOP-50	SnCu			301		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
173	382	U8	PDIP-20	AuPdNi			0		
173	383	U23	PDIP-20	AuPdNi	AuPdNi	SAC			
173	384	PTH's	PTH						
201	385	U1	TQFP-144	Sn			513		
201	386	U26	TSOP-50	SnCu			349		X
201	387	U41	TQFP-144	Sn			515		X
201	388	U9	CLCC-20	SACB			250		X
201	389	U27	PLCC-20	Sn			319		X
201	390	U18	BGA-225	SnPb	SAC		315	Broken wire	
201	391	U39	TSOP-50	SnCu			430		X
201	392	U56	BGA-225	SAC			305		X
201	393	U40	TSOP-50	SnCu			371		X
201	394	U3	TQFP-208	AuPdNi	AuPdNi	SACB	2		X
201	395	U13	CLCC-20	SACB			239		X
201	397	U57	TQFP-208	AuPdNi	AuPdNi	SACB	330		X
201	398	U14	CLCC-20	SACB			256		X
201	399	U15	PLCC-20	Sn			211		X
201	400	U25	TSOP-50	SnPb	SnCu	SACB	201		
201	403	U58	TQFP-144	Sn			332		X
201	404	U12	TSOP-50	SnPb	SnCu	SACB	288		X
201	406	U55	BGA-225	SAC			337		X
201	407	U17	CLCC-20	SACB			277		X
201	408	U2	BGA-225	SAC			63		
201	409	U31	TQFP-208	AuPdNi			426		X
201	410	U45	CLCC-20	SACB			275		X
201	411	U46	CLCC-20	SACB			218		X
201	412	U47	PLCC-20	Sn					
201	414	U24	TSOP-50	SnCu			307		
201	416	U4	BGA-225	SnPb	SAC		414		
201	417	U43	BGA-225	SAC			301		X
201	418	U20	TQFP-144	Sn			408		X
201	419	U21	BGA-225	SAC			258		
201	420	U44	BGA-225	SAC			304		X
201	421	U61	TSOP-50	SnCu			367		X
201	422	U54	PLCC-20	Sn					
201	423	U48	TQFP-208	AuPdNi			511		X
201	424	U7	TQFP-144	Sn			347		X
201	425	U22	CLCC-20	SACB			305		X
201	426	U16	TSOP-50	SnCu			370		X
201	428	U11	PDIP-20	Sn					
201	429	U30	PDIP-20	Sn					
201	430	U35	PDIP-20	AuPdNi					
201	431	U38	PDIP-20	Sn					
201	432	U49	PDIP-20	AuPdNi					
201	433	U51	PDIP-20	Sn					
201	434	U59	PDIP-20	AuPdNi	AuPdNi	SnCu	428		
201	435	U63	PDIP-20	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
201	436	U5	BGA-225	SAC			129		
201	437	U6	BGA-225	SAC			152		
201	438	U34	TQFP-208	AuPdNi			475		X
201	439	U52	CLCC-20	SACB			268		X
201	440	U53	CLCC-20	SACB			302		X
201	441	U62	TSOP-50	SnCu			315		X
201	443	U10	CLCC-20	SACB			241		X
201	444	U28	PLCC-20	Sn					
201	445	U29	TSOP-50	SnCu			344		X
201	446	U8	PDIP-20	AuPdNi					
201	447	U23	PDIP-20	AuPdNi	AuPdNi	SnCu			
201	448	PTH's	PTH						
45	449	U1	TQFP-144	Sn					
45	450	U26	TSOP-50	SnPb			377		
45	451	U41	TQFP-144	Sn					X
45	452	U9	CLCC-20	SnPb			377		
45	453	U27	PLCC-20	Sn					
45	454	U18	BGA-225	SnPb	SnPb		322		
45	455	U39	TSOP-50	SnPb					
45	456	U56	BGA-225	SnPb			486		
45	457	U40	TSOP-50	SnPb			478		
45	458	U3	TQFP-208	AuPdNi	AuPdNi	SnPb	505		
45	459	U13	CLCC-20	SnPb			432		
45	461	U57	TQFP-208	AuPdNi	AuPdNi	SnPb			
45	462	U14	CLCC-20	SnPb			395		
45	463	U15	PLCC-20	Sn					
45	464	U25	TSOP-50	SnPb	SnPb	SnPb	186		
45	467	U58	TQFP-144	Sn					
45	468	U12	TSOP-50	SnPb	SnPb	SnPb	334		X
45	470	U55	BGA-225	SnPb			438		
45	471	U17	CLCC-20	SnPb			471		
45	472	U2	BGA-225	SnPb			323		
45	473	U31	TQFP-208	AuPdNi					
45	474	U45	CLCC-20	SnPb			500		X
45	475	U46	CLCC-20	SnPb			477		X
45	476	U47	PLCC-20	Sn					X
45	478	U24	TSOP-50	SnPb			396		
45	480	U4	BGA-225	SnPb	SnPb				
45	481	U43	BGA-225	SnPb			525		
45	482	U20	TQFP-144	Sn					
45	483	U21	BGA-225	SnPb			473		
45	484	U44	BGA-225	SnPb			513		
45	485	U61	TSOP-50	SnPb			522		
45	486	U54	PLCC-20	Sn					
45	487	U48	TQFP-208	AuPdNi					
45	488	U7	TQFP-144	Sn			522		
45	489	U22	CLCC-20	SnPb			528		
45	490	U16	TSOP-50	SnPb			327		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
45	492	U11	PDIP-20	Sn					
45	493	U30	PDIP-20	Sn					
45	494	U35	PDIP-20	AuPdNi					
45	495	U38	PDIP-20	Sn					
45	496	U49	PDIP-20	AuPdNi					
45	497	U51	PDIP-20	Sn					
45	498	U59	PDIP-20	AuPdNi	AuPdNi	SnPb	0		
45	499	U63	PDIP-20	Sn					
45	500	U5	BGA-225	SnPb			438		
45	501	U6	BGA-225	SnPb					
45	502	U34	TQFP-208	AuPdNi					
45	503	U52	CLCC-20	SnPb			493		
45	504	U53	CLCC-20	SnPb			533		
45	505	U62	TSOP-50	SnPb			505		
45	507	U10	CLCC-20	SnPb			460		
45	508	U28	PLCC-20	Sn					
45	509	U29	TSOP-50	SnPb			491		
45	510	U8	PDIP-20	AuPdNi					
45	511	U23	PDIP-20	AuPdNi	AuPdNi	SnPb			
45	512	PTH's	PTH						
200	513	U1	TQFP-144	Sn			526		
200	514	U26	TSOP-50	SnCu			368		
200	515	U41	TQFP-144	Sn					
200	516	U9	CLCC-20	SACB			229		X
200	517	U27	PLCC-20	Sn			0		X
200	518	U18	BGA-225	SnPb	SAC		337		
200	519	U39	TSOP-50	SnCu			414		X
200	520	U56	BGA-225	SAC			309		
200	521	U40	TSOP-50	SnCu			460		
200	522	U3	TQFP-208	AuPdNi	AuPdNi	SACB	19		X
200	523	U13	CLCC-20	SACB			242		X
200	525	U57	TQFP-208	AuPdNi	AuPdNi	SACB	521		
200	526	U14	CLCC-20	SACB			271		X
200	527	U15	PLCC-20	Sn					
200	528	U25	TSOP-50	SnPb	SnCu	SACB	22		X
200	531	U58	TQFP-144	Sn					
200	532	U12	TSOP-50	SnPb	SnCu	SACB	69		X
200	534	U55	BGA-225	SAC			314		
200	535	U17	CLCC-20	SACB			304		X
200	536	U2	BGA-225	SAC			272		
200	537	U31	TQFP-208	AuPdNi			505		X
200	538	U45	CLCC-20	SACB			269		X
200	539	U46	CLCC-20	SACB			307		X
200	540	U47	PLCC-20	Sn					
200	542	U24	TSOP-50	SnCu			353		
200	544	U4	BGA-225	SnPb	SAC		334		
200	545	U43	BGA-225	SAC			198		
200	546	U20	TQFP-144	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
200	547	U21	BGA-225	SAC			163		
200	548	U44	BGA-225	SAC			256		
200	549	U61	TSOP-50	SnCu			411		
200	550	U54	PLCC-20	Sn					
200	551	U48	TQFP-208	AuPdNi			469		
200	552	U7	TQFP-144	Sn			501		
200	553	U22	CLCC-20	SACB			302		X
200	554	U16	TSOP-50	SnCu			335		
200	556	U11	PDIP-20	Sn					
200	557	U30	PDIP-20	Sn					
200	558	U35	PDIP-20	AuPdNi					
200	559	U38	PDIP-20	Sn					
200	560	U49	PDIP-20	AuPdNi					
200	561	U51	PDIP-20	Sn					
200	562	U59	PDIP-20	AuPdNi	AuPdNi	SnCu			
200	563	U63	PDIP-20	Sn					
200	564	U5	BGA-225	SAC			100		
200	565	U6	BGA-225	SAC			231		
200	566	U34	TQFP-208	AuPdNi					
200	567	U52	CLCC-20	SACB			311		X
200	568	U53	CLCC-20	SACB			291		X
200	569	U62	TSOP-50	SnCu			347		
200	571	U10	CLCC-20	SACB			247		X
200	572	U28	PLCC-20	Sn					
200	573	U29	TSOP-50	SnCu			317		
200	574	U8	PDIP-20	AuPdNi					
200	575	U23	PDIP-20	AuPdNi	AuPdNi	SnCu			
200	576	PTH's	PTH						
203	577	U1	TQFP-144	Sn			430		
203	578	U26	TSOP-50	SnCu			342		X
203	579	U41	TQFP-144	Sn			482		
203	580	U9	CLCC-20	SACB			252		X
203	581	U27	PLCC-20	Sn					
203	582	U18	BGA-225	SnPb	SAC		392		
203	583	U39	TSOP-50	SnCu			331		X
203	584	U56	BGA-225	SAC			255		X
203	585	U40	TSOP-50	SnCu			446		
203	586	U3	TQFP-208	AuPdNi	AuPdNi	SACB	42		X
203	587	U13	CLCC-20	SACB			260		X
203	589	U57	TQFP-208	AuPdNi	AuPdNi	SACB	376		X
203	590	U14	CLCC-20	SACB			253		X
203	591	U15	PLCC-20	Sn			314		
203	592	U25	TSOP-50	SnPb	SnCu	SACB	153		X
203	595	U58	TQFP-144	Sn					
203	596	U12	TSOP-50	SnPb	SnCu	SACB	244		X
203	598	U55	BGA-225	SAC			301		X
203	599	U17	CLCC-20	SACB			255		X
203	600	U2	BGA-225	SAC			193		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
203	601	U31	TQFP-208	AuPdNi			505		X
203	602	U45	CLCC-20	SACB			278		X
203	603	U46	CLCC-20	SACB			292		X
203	604	U47	PLCC-20	Sn					
203	606	U24	TSOP-50	SnCu			319		X
203	608	U4	BGA-225	SnPb	SAC		455		
203	609	U43	BGA-225	SAC			207		
203	610	U20	TQFP-144	Sn					
203	611	U21	BGA-225	SAC			176		
203	612	U44	BGA-225	SAC			274		
203	613	U61	TSOP-50	SnCu			385		
203	614	U54	PLCC-20	Sn					
203	615	U48	TQFP-208	AuPdNi			505		
203	616	U7	TQFP-144	Sn			354		
203	617	U22	CLCC-20	SACB			230		X
203	618	U16	TSOP-50	SnCu			317		X
203	620	U11	PDIP-20	Sn					
203	621	U30	PDIP-20	Sn					
203	622	U35	PDIP-20	AuPdNi					
203	623	U38	PDIP-20	Sn					
203	624	U49	PDIP-20	AuPdNi					
203	625	U51	PDIP-20	Sn					
203	626	U59	PDIP-20	AuPdNi	AuPdNi	SnCu			
203	627	U63	PDIP-20	Sn					
203	628	U5	BGA-225	SAC			158		
203	629	U6	BGA-225	SAC			198		
203	630	U34	TQFP-208	AuPdNi					
203	631	U52	CLCC-20	SACB			303		X
203	632	U53	CLCC-20	SACB			301		X
203	633	U62	TSOP-50	SnCu			344		
203	635	U10	CLCC-20	SACB			235		X
203	636	U28	PLCC-20	Sn					
203	637	U29	TSOP-50	SnCu			307		
203	638	U8	PDIP-20	AuPdNi					
203	639	U23	PDIP-20	AuPdNi	AuPdNi	SnCu			
203	640	PTH's	PTH						
174	641	U1	TQFP-144	Sn					
174	642	U26	TSOP-50	SnCu			426		
174	643	U41	TQFP-144	Sn					
174	644	U9	CLCC-20	SAC			252		X
174	645	U27	PLCC-20	Sn			309		
174	646	U18	BGA-225	SnPb	SAC		434		
174	647	U39	TSOP-50	SnCu			513		
174	648	U56	BGA-225	SAC			270		
174	649	U40	TSOP-50	SnCu			442		
174	650	U3	TQFP-208	AuPdNi	AuPdNi	SAC	521		
174	651	U13	CLCC-20	SAC			286		X
174	653	U57	TQFP-208	AuPdNi	AuPdNi	SAC	508		

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
174	654	U14	CLCC-20	SAC			260		X
174	655	U15	PLCC-20	Sn					
174	656	U25	TSOP-50	SnPb	SnCu	SAC	458		X
174	659	U58	TQFP-144	Sn			430		X
174	660	U12	TSOP-50	SnPb	SnCu	SAC	505		X
174	662	U55	BGA-225	SAC			280		
174	663	U17	CLCC-20	SAC			301		X
174	664	U2	BGA-225	SAC			224		
174	665	U31	TQFP-208	AuPdNi			511		X
174	666	U45	CLCC-20	SAC			254		X
174	667	U46	CLCC-20	SAC			302		X
174	668	U47	PLCC-20	Sn					
174	670	U24	TSOP-50	SnCu			378		X
174	672	U4	BGA-225	SnPb	SAC		169		
174	673	U43	BGA-225	SAC			212		
174	674	U20	TQFP-144	Sn			503		X
174	675	U21	BGA-225	SAC			148		
174	676	U44	BGA-225	SAC			193		
174	677	U61	TSOP-50	SnCu			360		X
174	678	U54	PLCC-20	Sn					
174	679	U48	TQFP-208	AuPdNi			472		X
174	680	U7	TQFP-144	Sn			474		X
174	681	U22	CLCC-20	SAC			213		X
174	682	U16	TSOP-50	SnCu			323		X
174	684	U11	PDIP-20	Sn					
174	685	U30	PDIP-20	Sn					
174	686	U35	PDIP-20	AuPdNi					
174	687	U38	PDIP-20	Sn					
174	688	U49	PDIP-20	AuPdNi					
174	689	U51	PDIP-20	Sn					
174	690	U59	PDIP-20	AuPdNi	AuPdNi	SAC	334		
174	691	U63	PDIP-20	Sn					
174	692	U5	BGA-225	SAC			240		
174	693	U6	BGA-225	SAC			130		
174	694	U34	TQFP-208	AuPdNi			515		
174	695	U52	CLCC-20	SAC			252		X
174	696	U53	CLCC-20	SAC			258		X
174	697	U62	TSOP-50	SnCu			334		X
174	699	U10	CLCC-20	SAC			301		X
174	700	U28	PLCC-20	Sn					
174	701	U29	TSOP-50	SnCu			340		
174	702	U8	PDIP-20	AuPdNi					
174	703	U23	PDIP-20	AuPdNi	AuPdNi	SAC	424		
174	704	PTH's	PTH						
68	705	U1	TQFP-144	Sn					
68	706	U26	TSOP-50	SnPb			398		X
68	707	U41	TQFP-144	Sn					X
68	708	U9	CLCC-20	SnPb			419		X

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
68	709	U27	PLCC-20	Sn					
68	710	U18	BGA-225	SnPb	SnPb		410		X
68	711	U39	TSOP-50	SnPb			425		X
68	712	U56	BGA-225	SnPb			353		X
68	713	U40	TSOP-50	SnPb			511		X
68	714	U3	TQFP-208	AuPdNi	AuPdNi	SnPb	307		
68	715	U13	CLCC-20	SnPb			315		X
68	717	U57	TQFP-208	AuPdNi	AuPdNi	SnPb	305		X
68	718	U14	CLCC-20	SnPb			233		X
68	719	U15	PLCC-20	Sn					
68	720	U25	TSOP-50	SnPb	SnPb	SnPb	258		X
68	723	U58	TQFP-144	Sn					
68	724	U12	TSOP-50	SnPb	SnPb	SnPb	261		X
68	726	U55	BGA-225	SnPb			356		X
68	727	U17	CLCC-20	SnPb			371		X
68	728	U2	BGA-225	SnPb			276		
68	729	U31	TQFP-208	AuPdNi					X
68	730	U45	CLCC-20	SnPb			421		X
68	731	U46	CLCC-20	SnPb			410		X
68	732	U47	PLCC-20	Sn					X
68	734	U24	TSOP-50	SnPb			383		X
68	736	U4	BGA-225	SnPb	SnPb		312		
68	737	U43	BGA-225	SnPb			376		
68	738	U20	TQFP-144	Sn					
68	739	U21	BGA-225	SnPb			387		
68	740	U44	BGA-225	SnPb			415		
68	741	U61	TSOP-50	SnPb			473		
68	742	U54	PLCC-20	Sn					
68	743	U48	TQFP-208	AuPdNi			510		
68	744	U7	TQFP-144	Sn			387		
68	745	U22	CLCC-20	SnPb			304		
68	746	U16	TSOP-50	SnPb			336		
68	748	U11	PDIP-20	Sn					
68	749	U30	PDIP-20	Sn					
68	750	U35	PDIP-20	AuPdNi					
68	751	U38	PDIP-20	Sn					
68	752	U49	PDIP-20	AuPdNi					
68	753	U51	PDIP-20	Sn					
68	754	U59	PDIP-20	AuPdNi	AuPdNi	SnPb			
68	755	U63	PDIP-20	Sn					
68	756	U5	BGA-225	SnPb			259		
68	757	U6	BGA-225	SnPb			247		
68	758	U34	TQFP-208	AuPdNi					
68	759	U52	CLCC-20	SnPb			416		
68	760	U53	CLCC-20	SnPb			404		X
68	761	U62	TSOP-50	SnPb			422		
68	763	U10	CLCC-20	SnPb			369		X
68	764	U28	PLCC-20	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
68	765	U29	TSOP-50	SnPb			413		
68	766	U8	PDIP-20	AuPdNi					
68	767	U23	PDIP-20	AuPdNi	AuPdNi	SnPb			
68	768	PTH's	PTH						
66	769	U1	TQFP-144	Sn					
66	770	U26	TSOP-50	SnPb			373		X
66	771	U41	TQFP-144	Sn					X
66	772	U9	CLCC-20	SnPb			304		X
66	773	U27	PLCC-20	Sn					X
66	774	U18	BGA-225	SnPb	SnPb		308		
66	775	U39	TSOP-50	SnPb			378		X
66	776	U56	BGA-225	SnPb			305		
66	777	U40	TSOP-50	SnPb			413		
66	778	U3	TQFP-208	AuPdNi	AuPdNi	SnPb	206		X
66	779	U13	CLCC-20	SnPb			268		X
66	781	U57	TQFP-208	AuPdNi	AuPdNi	SnPb	400		X
66	782	U14	CLCC-20	SnPb			301		X
66	783	U15	PLCC-20	Sn					
66	784	U25	TSOP-50	SnPb	SnPb	SnPb	210		
66	787	U58	TQFP-144	Sn					
66	788	U12	TSOP-50	SnPb	SnPb	SnPb	193		X
66	790	U55	BGA-225	SnPb			307		
66	791	U17	CLCC-20	SnPb			319		X
66	792	U2	BGA-225	SnPb			197		
66	793	U31	TQFP-208	AuPdNi			459		X
66	794	U45	CLCC-20	SnPb			343		X
66	795	U46	CLCC-20	SnPb			302		
66	796	U47	PLCC-20	Sn					
66	798	U24	TSOP-50	SnPb			373		
66	800	U4	BGA-225	SnPb	SnPb		305		
66	801	U43	BGA-225	SnPb			368		
66	802	U20	TQFP-144	Sn					
66	803	U21	BGA-225	SnPb			379		
66	804	U44	BGA-225	SnPb			436		
66	805	U61	TSOP-50	SnPb			344		
66	806	U54	PLCC-20	Sn					
66	807	U48	TQFP-208	AuPdNi					
66	808	U7	TQFP-144	Sn			488		
66	809	U22	CLCC-20	SnPb			389		X
66	810	U16	TSOP-50	SnPb			332		
66	812	U11	PDIP-20	Sn					
66	813	U30	PDIP-20	Sn					
66	814	U35	PDIP-20	AuPdNi					
66	815	U38	PDIP-20	Sn					
66	816	U49	PDIP-20	AuPdNi					
66	817	U51	PDIP-20	Sn					
66	818	U59	PDIP-20	AuPdNi	AuPdNi	SnPb			
66	819	U63	PDIP-20	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
66	820	U5	BGA-225	SnPb			313		
66	821	U6	BGA-225	SnPb			415		
66	822	U34	TQFP-208	AuPdNi					
66	823	U52	CLCC-20	SnPb			424		
66	824	U53	CLCC-20	SnPb			365		
66	825	U62	TSOP-50	SnPb			371		
66	827	U10	CLCC-20	SnPb			274		X
66	828	U28	PLCC-20	Sn					
66	829	U29	TSOP-50	SnPb			383		
66	830	U8	PDIP-20	AuPdNi					
66	831	U23	PDIP-20	AuPdNi	AuPdNi	SnPb			
66	832	PTH's	PTH						
176	833	U1	TQFP-144	Sn			471		
176	834	U26	TSOP-50	SnCu			318		X
176	835	U41	TQFP-144	Sn			415		X
176	836	U9	CLCC-20	SAC			273		X
176	837	U27	PLCC-20	Sn					X
176	838	U18	BGA-225	SnPb	SAC		305		
176	839	U39	TSOP-50	SnCu			417		X
176	840	U56	BGA-225	SAC			308		
176	841	U40	TSOP-50	SnCu			434		X
176	842	U3	TQFP-208	AuPdNi	AuPdNi	SAC	107		X
176	843	U13	CLCC-20	SAC			236		X
176	845	U57	TQFP-208	AuPdNi	AuPdNi	SAC	339		
176	846	U14	CLCC-20	SAC			237		X
176	847	U15	PLCC-20	Sn					
176	848	U25	TSOP-50	SnPb	SnCu	SAC	256		X
176	851	U58	TQFP-144	Sn			313		
176	852	U12	TSOP-50	SnPb	SnCu	SAC	338		
176	854	U55	BGA-225	SAC			318		
176	855	U17	CLCC-20	SAC			301		X
176	856	U2	BGA-225	SAC			133		
176	857	U31	TQFP-208	AuPdNi			422		X
176	858	U45	CLCC-20	SAC			313		X
176	859	U46	CLCC-20	SAC			303		X
176	860	U47	PLCC-20	Sn					
176	862	U24	TSOP-50	SnCu			306		X
176	864	U4	BGA-225	SnPb	SAC		460		
176	865	U43	BGA-225	SAC			303		
176	866	U20	TQFP-144	Sn			482		X
176	867	U21	BGA-225	SAC			118		
176	868	U44	BGA-225	SAC			215		
176	869	U61	TSOP-50	SnCu			318		X
176	870	U54	PLCC-20	Sn					
176	871	U48	TQFP-208	AuPdNi			358		X
176	872	U7	TQFP-144	Sn			319		X
176	873	U22	CLCC-20	SAC			275		X
176	874	U16	TSOP-50	SnCu			317		X

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
176	876	U11	PDIP-20	Sn					
176	877	U30	PDIP-20	Sn					
176	878	U35	PDIP-20	AuPdNi					
176	879	U38	PDIP-20	Sn					
176	880	U49	PDIP-20	AuPdNi					
176	881	U51	PDIP-20	Sn					
176	882	U59	PDIP-20	AuPdNi	AuPdNi	SAC	440		
176	883	U63	PDIP-20	Sn					
176	884	U5	BGA-225	SAC			119		
176	885	U6	BGA-225	SAC			128		
176	886	U34	TQFP-208	AuPdNi			515		X
176	887	U52	CLCC-20	SAC			267		X
176	888	U53	CLCC-20	SAC			257		X
176	889	U62	TSOP-50	SnCu			305		X
176	891	U10	CLCC-20	SAC			285		X
176	892	U28	PLCC-20	Sn					
176	893	U29	TSOP-50	SnCu			319		
176	894	U8	PDIP-20	AuPdNi					
176	895	U23	PDIP-20	AuPdNi	AuPdNi	SAC	514		
176	896	PTH's	PTH						
204	897	U1	TQFP-144	Sn			486		
204	898	U26	TSOP-50	SnCu			375		
204	899	U41	TQFP-144	Sn					
204	900	U9	CLCC-20	SACB			257		X
204	901	U27	PLCC-20	Sn					
204	902	U18	BGA-225	SnPb	SAC		261		
204	903	U39	TSOP-50	SnCu			466		
204	904	U56	BGA-225	SAC			374		
204	905	U40	TSOP-50	SnCu			481		
204	906	U3	TQFP-208	AuPdNi	AuPdNi	SACB	5		X
204	907	U13	CLCC-20	SACB			222		X
204	909	U57	TQFP-208	AuPdNi	AuPdNi	SACB	512		
204	910	U14	CLCC-20	SACB			415		
204	911	U15	PLCC-20	Sn					
204	912	U25	TSOP-50	SnPb	SnCu	SACB	263		X
204	915	U58	TQFP-144	Sn					
204	916	U12	TSOP-50	SnPb	SnCu	SACB	254		X
204	918	U55	BGA-225	SAC			435		
204	919	U17	CLCC-20	SACB			250		X
204	920	U2	BGA-225	SAC			155		
204	921	U31	TQFP-208	AuPdNi			487		
204	922	U45	CLCC-20	SACB			301		X
204	923	U46	CLCC-20	SACB			304		X
204	924	U47	PLCC-20	Sn					
204	926	U24	TSOP-50	SnCu			388		
204	928	U4	BGA-225	SnPb	SAC				
204	929	U43	BGA-225	SAC			306		
204	930	U20	TQFP-144	Sn					

Board SN	Anatech Channel	RefDes	Component	Finish Before Rework	Finish After Rework	Rework Wire	Cycles at Failure	Comments	Missing After CET
204	931	U21	BGA-225	SAC			272		
204	932	U44	BGA-225	SAC			342		
204	933	U61	TSOP-50	SnCu			405		
204	934	U54	PLCC-20	Sn					
204	935	U48	TQFP-208	AuPdNi					
204	936	U7	TQFP-144	Sn			373		
204	937	U22	CLCC-20	SACB			305		X
204	938	U16	TSOP-50	SnCu			384		
204	940	U11	PDIP-20	Sn					
204	941	U30	PDIP-20	Sn					
204	942	U35	PDIP-20	AuPdNi					
204	943	U38	PDIP-20	Sn					
204	944	U49	PDIP-20	AuPdNi			0		
204	945	U51	PDIP-20	Sn					
204	946	U59	PDIP-20	AuPdNi	AuPdNi	SnCu	523		
204	947	U63	PDIP-20	Sn					
204	948	U5	BGA-225	SAC			42		
204	949	U6	BGA-225	SAC			229		
204	950	U34	TQFP-208	AuPdNi					
204	951	U52	CLCC-20	SACB			301		
204	952	U53	CLCC-20	SACB			293		X
204	953	U62	TSOP-50	SnCu			350		
204	955	U10	CLCC-20	SACB			198		X
204	956	U28	PLCC-20	Sn					
204	957	U29	TSOP-50	SnCu			376		X
204	958	U8	PDIP-20	AuPdNi					
204	959	U23	PDIP-20	AuPdNi	AuPdNi	SnCu			
204	960	PTH's	PTH						

Appendix C: Hybrid Assembly Raw Test Data

Table 23 Hybrid Test Vehicle Raw Data

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at Failure	Comments	Missing After CET
303	1	U19	CSP-100	SnPb	SnPb	229		
303	2	U32	Hybrid-30	SnPb	SnPb	229		
303	3	U33	Hybrid-30	SnPb	SnPb	120		
303	4	U36	CSP-100	SnPb	SnPb	314		
303	5	U37	CSP-100	SnPb	SnPb	229		
303	6	U42	CSP-100	SnPb	SnPb	217		
303	7	U50	Hybrid-30	SnPb	SnPb	437		
303	8	U60	CSP-100	SnPb	SnPb	285		
325	9	U19	CSP-100	SnAgCu	SnAgCu	24		
325	10	U32	Hybrid-30	SnAgCu	SnAgCu	123		
325	11	U33	Hybrid-30	SnAgCu	SnAgCu	121		
325	12	U36	CSP-100	SnAgCu	SnAgCu	52		
325	13	U37	CSP-100	SnAgCu	SnAgCu	184		
325	14	U42	CSP-100	SnAgCu	SnAgCu	28		
325	15	U50	Hybrid-30	SnAgCu	SnAgCu	349		
325	16	U60	CSP-100	SnAgCu	SnAgCu	53		
335	33	U19	CSP-100	SnAgCu	SnAgCuBi	98		
335	34	U32	Hybrid-30	SnAgCuBi	SnAgCuBi			
335	35	U33	Hybrid-30	SnAgCuBi	SnAgCuBi			
335	36	U36	CSP-100	SnAgCu	SnAgCuBi	115		
335	37	U37	CSP-100	SnAgCu	SnAgCuBi	230		
335	38	U42	CSP-100	SnAgCu	SnAgCuBi	106		
335	39	U50	Hybrid-30	SnAgCuBi	SnAgCuBi			
335	40	U60	CSP-100	SnAgCu	SnAgCuBi	156		
332	41	U19	CSP-100	SnAgCu	SnAgCuBi	36		
332	42	U32	Hybrid-30	SnAgCuBi	SnAgCuBi	330		
332	43	U33	Hybrid-30	SnAgCuBi	SnAgCuBi	232		
332	44	U36	CSP-100	SnAgCu	SnAgCuBi	146		
332	45	U37	CSP-100	SnAgCu	SnAgCuBi	135		
332	46	U42	CSP-100	SnAgCu	SnAgCuBi	99		
332	47	U50	Hybrid-30	SnAgCuBi	SnAgCuBi			
332	48	U60	CSP-100	SnAgCu	SnAgCuBi	177		
301	65	U19	CSP-100	SnPb	SnPb	127		
301	66	U32	Hybrid-30	SnPb	SnPb	449		
301	67	U33	Hybrid-30	SnPb	SnPb	410		
301	68	U36	CSP-100	SnPb	SnPb	280		
301	69	U37	CSP-100	SnPb	SnPb	15		
301	70	U42	CSP-100	SnPb	SnPb	149		
301	71	U50	Hybrid-30	SnPb	SnPb	449		
301	72	U60	CSP-100	SnPb	SnPb	44		
323	73	U19	CSP-100	SnAgCu	SnAgCu	297		
323	74	U32	Hybrid-30	SnAgCu	SnAgCu	356		

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at Failure	Comments	Missing After CET
323	75	U33	Hybrid-30	SnAgCu	SnAgCu			
323	76	U36	CSP-100	SnAgCu	SnAgCu	299		
323	77	U37	CSP-100	SnAgCu	SnAgCu	304		
323	78	U42	CSP-100	SnAgCu	SnAgCu	332		
323	79	U50	Hybrid-30	SnAgCu	SnAgCu			
323	80	U60	CSP-100	SnAgCu	SnAgCu	332		
327	97	U19	CSP-100	SnAgCu	SnAgCu	197		
327	98	U32	Hybrid-30	SnAgCu	SnAgCu	310		
327	99	U33	Hybrid-30	SnAgCu	SnAgCu	309		
327	100	U36	CSP-100	SnAgCu	SnAgCu	74		
327	101	U37	CSP-100	SnAgCu	SnAgCu	165		
327	102	U42	CSP-100	SnAgCu	SnAgCu	204		
327	103	U50	Hybrid-30	SnAgCu	SnAgCu	339		
327	104	U60	CSP-100	SnAgCu	SnAgCu	190		
337	105	U19	CSP-100	SnAgCu	SnAgCuBi	152		
337	106	U32	Hybrid-30	SnAgCuBi	SnAgCuBi			
337	107	U33	Hybrid-30	SnAgCuBi	SnAgCuBi	475		
337	108	U36	CSP-100	SnAgCu	SnAgCuBi	2	Excluded	
337	109	U37	CSP-100	SnAgCu	SnAgCuBi	110		
337	110	U42	CSP-100	SnAgCu	SnAgCuBi	164		
337	111	U50	Hybrid-30	SnAgCuBi	SnAgCuBi			
337	112	U60	CSP-100	SnAgCu	SnAgCuBi	112		
306	129	U19	CSP-100	SnPb	SnPb	305		
306	130	U32	Hybrid-30	SnPb	SnPb	122		
306	131	U33	Hybrid-30	SnPb	SnPb	331		
306	132	U36	CSP-100	SnPb	SnPb	122		
306	133	U37	CSP-100	SnPb	SnPb	297		
306	134	U42	CSP-100	SnPb	SnPb	227		
306	135	U50	Hybrid-30	SnPb	SnPb	315		
306	136	U60	CSP-100	SnPb	SnPb	229		
302	161	U19	CSP-100	SnPb	SnPb	348		
302	162	U32	Hybrid-30	SnPb	SnPb	437		
302	163	U33	Hybrid-30	SnPb	SnPb	316		
302	164	U36	CSP-100	SnPb	SnPb	225		
302	165	U37	CSP-100	SnPb	SnPb	229		
302	166	U42	CSP-100	SnPb	SnPb	283		
302	167	U50	Hybrid-30	SnPb	SnPb	222		
302	168	U60	CSP-100	SnPb	SnPb	449		
333	169	U19	CSP-100	SnAgCu	SnAgCuBi	206		
333	170	U32	Hybrid-30	SnAgCuBi	SnAgCuBi	449		
333	171	U33	Hybrid-30	SnAgCuBi	SnAgCuBi	303		
333	172	U36	CSP-100	SnAgCu	SnAgCuBi	80		
333	173	U37	CSP-100	SnAgCu	SnAgCuBi	230		
333	174	U42	CSP-100	SnAgCu	SnAgCuBi	163		
333	175	U50	Hybrid-30	SnAgCuBi	SnAgCuBi			

Board SN	Anatech Channel	RefDes	Component	Finish	Paste	Cycles at Failure	Comments	Missing After CET
333	176	U60	CSP-100	SnAgCu	SnAgCuBi	113		
336	193	U19	CSP-100	SnAgCu	SnAgCuBi	149		
336	194	U32	Hybrid-30	SnAgCuBi	SnAgCuBi	437		
336	195	U33	Hybrid-30	SnAgCuBi	SnAgCuBi	344		
336	196	U36	CSP-100	SnAgCu	SnAgCuBi	59		
336	197	U37	CSP-100	SnAgCu	SnAgCuBi	102		
336	198	U42	CSP-100	SnAgCu	SnAgCuBi	102		
336	199	U50	Hybrid-30	SnAgCuBi	SnAgCuBi	343		
336	200	U60	CSP-100	SnAgCu	SnAgCuBi	65		
326	201	U19	CSP-100	SnAgCu	SnAgCu	314		
326	202	U32	Hybrid-30	SnAgCu	SnAgCu	229		
326	203	U33	Hybrid-30	SnAgCu	SnAgCu	105		
326	204	U36	CSP-100	SnAgCu	SnAgCu	95		
326	205	U37	CSP-100	SnAgCu	SnAgCu	255		
326	206	U42	CSP-100	SnAgCu	SnAgCu	171		
326	207	U50	Hybrid-30	SnAgCu	SnAgCu			
326	208	U60	CSP-100	SnAgCu	SnAgCu	146		
324	225	U19	CSP-100	SnAgCu	SnAgCu	29		
324	226	U32	Hybrid-30	SnAgCu	SnAgCu	123		
324	227	U33	Hybrid-30	SnAgCu	SnAgCu	121		
324	228	U36	CSP-100	SnAgCu	SnAgCu	75		
324	229	U37	CSP-100	SnAgCu	SnAgCu	61		
324	230	U42	CSP-100	SnAgCu	SnAgCu	44		
324	231	U50	Hybrid-30	SnAgCu	SnAgCu	332		
324	232	U60	CSP-100	SnAgCu	SnAgCu	37		
305	233	U19	CSP-100	SnPb	SnPb	344		
305	234	U32	Hybrid-30	SnPb	SnPb	151		
305	235	U33	Hybrid-30	SnPb	SnPb	36		
305	236	U36	CSP-100	SnPb	SnPb	321		
305	237	U37	CSP-100	SnPb	SnPb	312		
305	238	U42	CSP-100	SnPb	SnPb	315		
305	239	U50	Hybrid-30	SnPb	SnPb	151		
305	240	U60	CSP-100	SnPb	SnPb	318		

List of Symbols, Abbreviations and Acronyms

Ag	Silver
Au	Gold
AuPdNi	Gold-Palladium-Nickel finish
BGA	Ball grid array
Bi	Bismuth
CCA	Circuit card assembly
CET	Combined environments test
CLCC	Ceramic leadless chip carrier
CSP	Chip scale package
Cu	Copper
DoD	Department of Defense
EPA	Environmental Protection Agency
ETL	Environmental Test Laboratory
HASL	Hot air solder level
HALT	Highly accelerated life test
HASS	Highly accelerated stress screen
I/O	Input/output
JCAA	Joint Council on Aging Aircraft
JG-PP	Joint Group on Pollution Prevention
JTP	Joint Test Protocol
JTR	Joint Test Report
NASA	National Aeronautical and Space Administration
Ni	Nickel
OSP	Organic solderability preservative
Pd	Palladium
PDIP	Plastic dual-inline package
PLCC	Plastic leaded chip carrier
PTH	Plated-through hole
RoHS	Restriction of Hazardous Substances
SAC	Tin-Silver-Copper solder alloy
SACB	Tin-Silver-Copper-Bismuth solder alloy
SMT	Surface mount technology
Sn	Tin
SnAgCu	Tin-Silver-Copper solder alloy

SnAgCuBi	Tin-Silver-Copper-Bismuth solder alloy
SnCu	Tin-copper solder alloy
SnPb	Tin-Lead solder alloy
Tg	Glass transition temperature
TQFP	Thin quad flat package
TSOP	Thin small outline package
WEEE	Waste from Electrical and Electronic Equipment Directive